NATIONAL DEFENSE UNIVERSITY
INSTITUTE FOR NATIONAL STRATEGIC STUDIES

DOMINANT BATTLESPACE KNOWLEDGE

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Introduction by
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THE CENTER FOR ADVANCED CONCEPTS AND TECHNOLOGY

Directorate of Advanced Concepts, Technologies, and Information Strategies (ACTIS)

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Foreword

The Department of Defense has been successfully exploiting rapidly developing advances in information technology for military gain. On tomorrow's multidimensional battlefield—or "battlespace"—the increased density, acuity, and connectivity of sensors and many other information devices may allow U.S. Armed Forces to see almost everything worth seeing in real or near-real time. Such enhanced *vision* of the battlespace is no doubt a significant military advantage, but a question remains: How do we achieve dominant battlefield *knowledge*, namely the ability to *understand* what we see and *act* on it decisively?

The papers collected here address the most critical aspects of that problem—to wit: If the United States develops the means to acquire dominant battlespace knowledge (DBK), how might that affect the way it goes the war, the circumstances under which force can and will be used, the purposes for its employment, and the resulting alterations of the global geomilitary environment? Of particular interest is how the authors view the influence of DBK in light of the shift from global to regional stability issues that marks the post-Cold War world.

While no definitive answer has yet emerged, it is clear that the implications of so profound a change in military technology are critical to the structure and function of the U.S. Armed Forces. In working toward a definitive answer, the authors of this volume make an important contribution to a debate whose resolution will shape the decades to come.

Ervin J. Rokke

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Introduction

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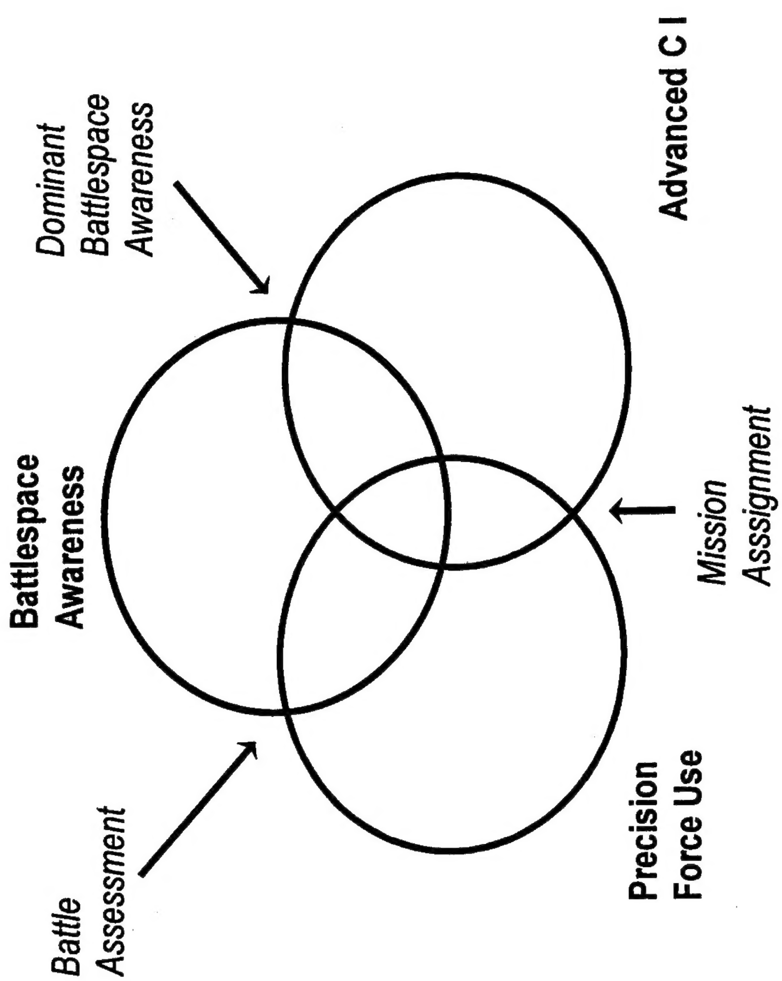
Three simultaneous revolutions have pushed us toward change. The first is from the revolution in world affairs brought about by the implosion of the Soviet Union and the end of the Cold War. We are also experiencing a related revolution—the reduction in the defense budget, which began almost a decade ago and accelerated because of the demise of the Soviet Union. The third revolution affecting the U.S. military is what some call the revolution in military affairs. In part because of earlier investments, particularly in technologies, our military capability is improving rapidly, and these improvements point toward a qualitative jump in our ability to use military force effectively. We will be the first nation to pass through the revolution, emerging with different strengths that can give us an edge across the entire spectrum of contingencies against which the nation may need to commit its military.

The Emerging U.S. System of Systems

What kinds of requirements are emerging from these revolutions? They fall into three general categories, which, for convenience, we may call intelligence, command and control, and precision force (see Figure 1 for an illustration of interrelationships):

Figure 1
A System of Systems



- The first category, intelligence, surveillance, and reconnaissance (ISR), involves sensor and reporting technologies associated with intelligence collection, surveillance, and reconnaissance, as well as the new means by which we are able to keep track of what our own forces are doing. Because of advances in this area, we are expanding quite dramatically our capacity to maintain real-time, all-weather awareness of what is occurring in and above a wide geographical area.

- The second is command, control, communications, computer applications, and intelligence processing—advanced $C^4$1, the technologies and techniques by which we translate the awareness of what is occurring in a broad geographical arena into an *understanding* of what is taking place there, and communicate that understanding quickly, surely, and accurately—in usable form—to combat forces. Advanced $C^4$1 is where processes like target identification, mission assignment and force allocation take place. In other words, it is the realm in which we convert the understanding of a battlespace to missions and assignments designed to alter, control, and dominate that battlespace.

- Then there is precision force, which many understand to be precision-guided weaponry, and it certainly includes this category of weapons. It is a broader concept, however, that emphasizes speed, accuracy, and precision in the use of force and therefore encompasses all our forces, the infantry as well as strategic bombers, and includes things like information warfare. This is the area in which the knowledge generated from the overlap of the first two areas leads to action. It is easy to miss the power

> generated by the interaction of ISR, advanced C41 and precision force, because we tend to see developments in each of the areas as discrete and separate. Consider Table 1, which lists some of the weapons and systems already budgeted and programmed that have entered the active inventories or will do so in the years ahead. Something about the way we plan and program in the Defense Department keeps us in compartmented perspectives. We are more adept at seeing some of the individual trees than that vast forest of military capability the individual systems are building, so it is easy to miss the fact that, together, these programs posit a qualitatively different military potential.

What is happening, driven in part by broad conceptual architectures, in part by serendipity, is the creation of a new *system of systems.* Merging our increasing capacity to gather real-time, all-weather information continuously with our increasing capacity to process and make sense of this voluminous data builds the realm of dominant battlespace knowledge (DBK). DBK involves everything from automated target recognition to knowledge of an opponent's operational scheme and the networks relied on to pursue that scheme. The result will be an increasing gap between U.S. military forces and any opponent in awareness and understanding of everything of military significance in any arena in which we may be engaged.

TABLE 1. Weapons and Systems In or Entering U.S. Military Inventories

ISR (sensors)	C4I	Precision Force
AWACS	GCCS	SFW
RIVET JOINT	MILSTAR	JSOW
EP-3E	JSIPS	TLAM (BLK III)
JSTARS	DISN	ATACMS/BAT
HASA	JUDI	SLAW
SBIR	C4I FTW	CALCM
TIER 2+	TADIL J	HAVE NAP
TIER 3-	TRAP	AGM-130
TARPS	TACSAT	HARM
MTI	JWICS	AIR HAWK
REMBAS	MIDS	SADARM
MAGIC LANTERN	SONET	HELLFIRE II
ISAR	LINK-16	TLAM (BLK IV)
FDS	DMS	JAVELIN
ATARS	SABER	THAAD

Likewise, our growing capacity to transfer DBK to all our forces, coupled with the real-time awareness of the

status of all our forces and the understanding of what they can do with their growing capacity to apply force with speed, accuracy, and precision, builds the realm of "near perfect" mission allocation. We will increasingly assign the right mission to the right force, matching our forces to the most successful course of action at both the tactical and operational levels of warfare. Further, our increasing capacity to use force faster, more accurately, and more precisely over greater distances and interacting with the advances in ISR will build a qualitatively better realm of battle assessment. We will know the effects of our actions—and understand what those effects mean—with far more fidelity, far earlier than anything we have experienced to date. This dominant knowledge, in turn, will make any subsequent actions we undertake even more effective, because we will truly be able to operate within the opponent's decision cycle, and the opponent's capacity to operate at all will have been greatly eroded.

This new system-of-systems capability is at the heart of the American revolution in military affairs (RMA). It embodies a new appreciation of joint military operations, for the system-of-systems depends ultimately on contributions from all the military services, a common appreciation of what we are building, and a common military doctrine.

This transition is inevitable, but the speed at which we complete it depends on recognition of what is emerging and on our defense planning and programming decisions over the next several years. If we decide to accelerate the transition, it can be completed early in the next century. We could therefore be on the other side of this new revolution in military affairs years, perhaps decades, before any other nation. This is important for many reasons; one of the most significant is that completing the revolution

offers us the opportunity to shape the international environment, rather than simply react to it.

This, then, is the essence of the argument in favor of accelerating RMA. It is a bold vision and a controversial one. Visions count, however, only if people try to make them real, and the professional military should not try to reify this one unless it holds up to honest critique. Let us turn to the five most serious criticisms that have surfaced so far.

Opponents Fight Back

Postmortems of the American experience in Vietnam include the suggestion that, although the United States could put men on the moon, it could not "win" in Vietnam because, unlike the inanimate moon, the opponent in Vietnam fought back. Does a version of this homily apply to the system-of-systems vision, in the sense that no matter how technologically sophisticated the U.S. military may become, small opponents would "fight back" by channeling their aggression in ways that circumvent, undermine, or neutralize the technology Americans bring to the conflict? Those making this argument do not usually get very specific about how an opponent might be able to do this. They sometimes allude to "people's war" or weapons of mass destruction or terrorism without explaining what it is about these forms of aggression that would necessarily defy the capabilities inherent in the system-of-systems—but their general point is a serious one. The conflicts we face will remain competitions among thinking, learning, and adaptive human beings, so we need to recognize that any future opponent could diligently and intelligently try to counter capabilities the system-of-systems gives us.

Assuming opponents will try to counter the system-of-systems does not mean they will succeed, however. History is replete with examples of how advances in military technology were eventually countered or matched. Yet history also has intriguing examples of real revolutions in military affairs—Guderian's *blitzkrieg*, Ellis's vision of amphibious warfare, and the nuclear revolution come to mind. These gave the revolutionaries dominance in conflict, in some cases for extended periods. None of these revolutions lasted forever, and the edge they provided ultimately eroded, but it was good to have the edge, not only because it paid off in conflict, but also because it gave leverage to foreign policy.

A better consideration than historical precedent is the inherent character of the system-of-systems. The technology it rests upon emphasizes flexibility and adaptability. It will enable the U.S. military to know more about the flow of conflict than an opponent and to operate better within the decision cycle of that opponent. It will arm American forces with the means of learning faster on a battlefield (traditional or otherwise) and being more adaptable and flexible than an opponent. In other words, it starts from the fundamental assumption shared by its critics: war is a human contest that rewards innovation, learning, adaptability, and flexibility. The system-of-systems theory suggests that Americas can be better in meeting those criteria, criteria armed with technology designed to support them, than others can be without the technology

Relying on Technology is An Achilles' Heel

One of the most frequently leveled criticisms by those who think the vision is really a mirage is that the reliance on "information" technologies—the kind of sensors, data processing and communications subsystems that appear in

Table 1—carries an inherent weakness that opponents can exploit: the vulnerability of such technologies to offensive information warfare, or "hacking." Do information technologies carry an electronic Achilles' heel that opponents can exploit? If so, heavy reliance on the system-of-systems might make the United States vulnerable to catastrophic failure in efforts to use it successfully in conflict.

There is, to be sure, great danger in relying on military systems that have exploitable flaws. Indeed, the characteristic that gives any system its potency—that the parts of a system enhance the effectiveness of one another—also makes some systems susceptible to catastrophic failure if one of their central parts can be jeopardized. Yet there are some aspects of the system-of-systems that ought to alleviate if not refute these concerns.

First, the people implementing the vision are far from ignorant of the danger of inherent flaws. A great deal of thought, planning, money, and continual effort goes into reducing real or hypothetical vulnerability. A lot of that effort follows the same kind of approach used so successfully in the SSBN security program—namely, don't wait until someone else finds a vulnerability; instead, think and work continually to find and eliminate it first.

Second, the computer and communications technologies on which the system-of-systems are based are becoming less, not more, susceptible to the various forms of information warfare. A race will probably always exist between those who seek to ensure the security of information-based systems and those who seek to overcome their security measures. Yet, the trend favors the effort to increase, not degrade security. In part, this is because of the relative

"hardness" of the new generations of communications equipment. Fiber optic cable, for example, has physical characteristics that make it inherently more difficult to "tap" surreptitiously.

Third, there is a robust redundancy to the emerging American system-of-systems. This redundancy works against the possibility of breaking the whole system; it also means that if there are ways of successfully attacking parts of the system, the overall system would not collapse but rather would degrade slowly. In one sense, this is faint praise; we don't want the system-of-systems to degrade at all. In another sense it suggests an opponent would be defeated or dead before he could defend against, counter, or defeat the capabilities we could bring against him.

Clearly, none of this is cause for complacency; we need to continually bear in mind potential vulnerabilities and work hard to find and end them. Neither can a case be made that the vision is flawed or that moving to the system-of-systems carries more risk than sticking with the status quo.

It Applies Only to the Last War

Some argue that the system-of-systems may work only in a conflict similar to *Desert Storm,* with relatively open terrain and with an opponent who turns out to be scared and stupid, one who gives us enough time to amass an overwhelming force. That was the last war, however, not the next one. Future conflicts may take place in terrain less open, with an opponent not as militarily naive as Saddam Hussein, and against an army that is a lot more skilled in hiding. Urban areas, jungles, and mountains are as likely to be arenas as open deserts. There, it is argued, the system-of-systems is less applicable, and relying on it at the

expense of a force built for close combat, in very ambiguous tactical situations, is a recipe for failure.

However, the system-of-systems can apply *across* the spectrum of conflict . Americans will always seek the capacity to use military force with speed, precision, effectiveness and low risk to the participants. The dispositions, movements, and capabilities of an opponent's forces may be easier to discern in open desert than in the middle of Mogadishu or triple-canopied jungles, but this is no reason to refrain from trying to discern them. The fact is that the system-of-systems will give us far better capacity to do this, and with greater effectiveness and lower risk than we currently have. What other approach can better solve the military difficulties posed by the kinds of terrain, missions, and opponents we may face in the years ahead?

We owe the men and women who may be in harm's way every edge technology can provide. Technology will never be a substitute for courage or human toughness in conflict, but it can increase the likelihood that the tough and courageous will be successful.

The System-of-Systems Ignores the Fog and Friction of War

Some argue the vision refutes the wisdom of combat experience and military history regarding the fog and friction of war. War, they point out, is inherently chaotic and ambiguous. The only things certain about it are that you will know less than you need to and your strategies and plans will not work out as well as you had hoped. These critics appeal to observers as varied as Clausewitz and Sun Tzu as authorities and to personal anecdotes as proof.

Of course they are correct. Conflict is chaotic, confusing, and messy. We will never have *perfect* understanding of a battlefield, our systems and weapons will never work flawlessly *all the time*, and the forces we ask to wage war will never do everything correctly *every time.* The system-of-systems does not promise perfection; it promises to reduce the fog and friction of war faced by the U.S. military and to do so sufficiently to give the United States a radically better edge in conflict over any opponent, at least so long as the United States has the system-of-systems and the opponent does not.

Much of this hypothesis is susceptible to analysis. Over the last year, the joint warfare capabilities assessments have applied considerable analytic effort to testing it, and a lot more has to be done before we can say it's right or wrong. We can quantify the coming improvements in things like battlespace awareness, target recognition, connectivity, data exchange rates, weapons reach and accuracy, and destructive power. These all point to large jumps, quantitatively, over the remainder of this century. Impressive numbers do not necessarily constitute the RMA, however. Obviously, we must watch these assessments and analyses over the next year very carefully, but so far, the analytic view supports the vision that the United States is on the cusp of a qualitative change in its capability to use military force.

It's Not Broken; Don't Fix It

There is considerable agreement within the Pentagon on the central issues: that we ought to continue to develop our capacity to understand the battlespaces in which we may operate, to improve joint operations, and continue to pursue

the technologies that promise the RMA. The real issue is the rate at which we should go down these paths.

The amount of effort needed to accelerate the achievement of the vision is not substantial; most of the programs that drive the RMA are already funded. They will reach fruition relatively soon, and not all of them should necessarily be accelerated. Their significance is, after all, a function of their interaction. Accelerating some but not others may give only marginal gains; some simply cannot come any faster no matter how much money we throw at them.

At the center of the debate is whether we should take away from some programs and give to others. Such change is not new to Pentagon planning. What is new is the basic rationale for changing. In the past, change was driven either by the perception of threat (e.g., we developed new capabilities because of improvements our competitor, the Soviet Union, was making in military capabilities) or by the belief that things inside the military were broken enough to seek different solutions. The Army went through such a period of introspection after Vietnam.

Now, however, neither of these motivations is particularly relevant, so the intellectual basis for arguing for change cannot rest in traditional rationales. It rests, therefore, in a sense of opportunity to make high dividend changes that pay off in maintaining a U.S. military superiority beyond the turn of the century and in forging a new link between American military capabilities and American foreign policy, one better suited to the post-Cold War world.

The system-of-systems vision may provide a means of recementing this link. In an increasingly ambiguous world, where coalitions will parallel and perhaps replace alliances,

and where nations will look for continued U.S. leadership, smart, flexible, mobile, effective forces make sense.

DBK: OPPORTUNITY AND CHALLENGES

Stuart E. Johnson

The United States military has achieved a great deal of success in the post-Cold War era:

- We no longer face the most stressful of our missions: global competition with a peer military power.
- The quality of our troops is good and morale in the armed forces is high.
- Heavy investment in the procurement of weapon systems in the 1980s makes our forces equipped with weapons more capable and more modern than those possessed by any conceivable adversary.

Other factors are working in our favor in the short run. The Iraq of today is not the Iraq of 1990, North Korea's conventional forces equipment is deteriorating, and our own forces have been improved in the meantime. We have some breathing space during which we can think about the capabilities we will need in our armed forces a decade or two from today.

Still, there is little room for complacency. Regional aggressors, midsized powers such as Iraq and North Korea, while no match for the militaries of the United States and its allies overall, can mount a serious challenge to our interests in their own backyards. We must cope with this threat with diminishing resources. The defense budget has

been dropping steadily since the mid-1980s and is 35 percent smaller than a decade ago. The cuts have been deepest in the procurement account, which exceeded $120 billion in 1986 but dropped steadily to below $50 billion in 1995. This has led to a sharp drop in the number of weapon systems coming into the force structure in recent years, a trend that will continue for the immediate future. The capital stock of the U.S. military is beginning to age and the rate at which new weapon systems are being procured is well below the replacement rate for every major category of weapon system. In 10 to 15 years, our Armed Forces will be facing widespread obsolescence of a number of traditional military equipment items, most notably attack helicopters, bombers, submarines, and transport aircraft.

Force structure has been cut as well. Our forces are about 40 percent smaller today than when we drove Iraq out of Kuwait. Active ground and air forces are only slightly larger today than the forces actually deployed in *Desert Storm*. Indeed, were we to send a force the size of our *Desert Storm* deployment, it would require 80 percent of the active army and air force.

The new majority on Capitol Hill has expressed strong support for defense, but the actual increases proposed in the defense budget are modest. Moreover, as pressure to balance the federal budget continues, these increases are in peril.

We cannot ignore the multiplicity of demands being put on the military to support operations other than war and conflict at the low end of the spectrum. Since 1991, the U.S. military has been engaged in 14 operations involving forces of a company size or greater. While many of these have involved only modest-sized combat units, heavy

demands have been placed on support forces, in particular transport and logistical supply units. These forces, critical to the successful prosecution of a major regional conflict, have been stretched thin.

Choices must be made today. We cannot continue to live off the stocks of weapon systems acquired in the 1980s and replacing them one-for-one. Maintaining our forces in a high state of readiness and the full force structure is expensive and may not be sustainable. We have to think about doing business differently.

This study examines an approach to how we might fight a high intensity conflict—a major regional conflict—more effectively and more efficiently. The approach takes advantage of rapid advances in automatic data processing, sensor technology, and telecommunications to develop a system that provides our forces with DBK. The implications of this capability are far reaching and span the spectrum, from providing a broad operational level view of the battlefield to the possibility of targeting and striking targets within minutes of detection. This concept of warfighting allows us to address a number of problems that we face:

- *The cost of maintaining a force structure large enough to fight two major regional conflicts in a classical manner simultaneously.* Today we have forces that are assessed by the Department of Defense to be adequate to fight two major regional conflicts nearly simultaneously. The cost of maintaining this size a force and keeping them is a high state of readiness is high. Dominant battlespace knowledge, exploited wisely, provides a different way of doing business that

could be more efficient—blunting aggression at a lower cost.

- *Deploying large forces to a theater to fight an enemy that can deliver weapons of mass destruction.* Coupling dominant battlespace knowledge with precision guided munitions permits standoff delivery, even offshore delivery. This is useful because it puts high-value assets out of range of short-range ballistic missiles that can be used to deliver weapons of mass destruction. Even as potential adversaries acquire longer range delivery systems, the further back we keep our assets, the more we complicate the enemy's targeting. There is another advantage, if a regional aggressor in possession of weapons of mass destruction, especially nuclear weapons, tries to blackmail friendly host nations in the region. If Saddam had had a nuclear weapon system with sufficient range, he may well have threatened to strike Riyadh if Saudi Arabia allowed deployment of U.S. forces on its soil. Being able to operate off-shore, or well back from the battlefield, can go a long way to neutralizing the an aggressor's leverage against a friendly nation. This approach also reduces our logistics footprint in the theater and reduces the value of individual targets thereby presenting less lucrative targets for weapons of mass destruction. For example, since fewer munitions are needed per target kill, the transportation infrastructure can be more austere and munitions storage areas can be smaller. In sum, heavy dependence on ports, munitions depots, and a large transport network is relieved.

- *The time to respond to an aggression and bring firepower to the battlefield is reduced.* A system that

> provides dominant battlespace knowledge can provide a rapid reading of an aggressor's troop deployments and movements. We can then bring firepower to bear on key targets quickly, thereby allowing disruption or even blunting of an attack before we would have had time to deploy adequate ground and air forces into the theater itself. This capability would have been useful to augment Operation *Vigilant Warrior* where we deployed ground and air forces into the theater to check Iraq's moving four divisions forward to the Kuwait border. Indeed, the mere possession of this capability could have considerable deterrent power to augment that of forces in the theater.

To explore DBK in its many perspectives and ramifications, this volume hosts a series of essays. The first, "DBK and its Consequences," asks where the United States can get such a capability, what it can be used for, and how others might respond to it, and then concludes that the U.S. is approaching the ability to see everything of unambiguous military relevance on the battlefield, even if this capability will vary greatly by circumstance. With it, the U.S. can probably stop most cross-border blitzkrieg-style attacks, no small achievement. Others, however, may react in different ways. Apart from altering the battlefield (e.g., terrorism, weapons of mass destruction, information warfare), a canny adversary would reconfigure its forces to distribute its assets thinly, making it cost ineffective to attack it through stand-off precision weaponry. The United States in turn could respond by building vertical coalitions with allies at risk; our information flows would multiply the effectiveness of their organic defenses.

The second essay, "The Significance of DBK," is a detailed excursion of what DBK may provide to the two canonical

Major Regional Contingencies: a war in the Gulf, and an invasion across the Korean DMZ. The analysis is that the United States has a reasonable expectation of stopping an invasion in its track in the first scenario, and a good chance of prevailing, although not as quickly, in the second. It concludes that DBK permits shifting warfighting assets from strategic to more immediately effective tactical targeting; flattening hierarchies; and changing the planner's role from strategic allocator to resource assembler. The argument is also presented that there is need for a broad reexamination of how information is used in the war, one that starts from the bottom up rather than the top down.

"The Future of Command and Control with DBK" begins with the assumption that by the year 2005 we could obtain Dominant Battlefield Awareness and explores opportunities that this capability affords to design new command concepts and organizational structures. The ability to manage Command and Control effectively as well as manage our sensors, communications, and weapons systems to achieve a true System-of-Systems will be the key to leveraging the capabilities provided by emerging technologies to give us a winning edge.

"DBK and Future Warfare" argues that these technologies put the commander back in command. The ability to manage complex operations in near real-time permits expanded operational synergies, from the merely integrated to the truly coherent. They permit the reemergence of decisive combat in lieu of differential attrition. Commanders so armed will be able to maneuver inside the cycle times of their opponents, take advantage of more rapid learning, and achieve phase-change dominance—the ability to, by striking, force the enemy to undertake a debilitating change of phase from one mode of operations to another. Exploiting DBK however, means that it be

applied across the entire cognitive hierarchy—from data, to information, knowledge, and finally, understanding.

To "do the math", as a popular electronic game manufacturer urges, "DBK and Autonomous Weapons" replays Operation *Vigilant Warrior* but with advanced weaponry such as brilliant anti-tank munitions, sensor-fuzed weapons, and wide-area mines. Using a canonical force mix and weapons load-out, this study concludes that autonomous weapons may be the key force multipliers in such scenarios permitting very high rates of attrition within the first few days of combat.

By contrast, "Just-in-Time Warfare" sees the potential of DBK in precisely the opposite way, when information on the battlefield is available, but difficult choices must be made about engagements (in part because of resource limitations). DBK permits forces to mass at the point of contact, coming together to engage the point of the enemy spear, and disengaging with equal rapidity. To support such a capability requires a sea change in the organization of military force: concepts such as virtual organizations, command-by-negation, automated rules of engagement and cooperation, and just-in-time logistics play a leading role.

DBK AND ITS CONSEQUENCES

Martin C. Libicki

How would U.S. military operations be affected if we enjoyed DBK in an area associated with a major regional contingency? This question is addressed in several parts:

- What is the most optimistic but plausible assessment of how well (and by what means) U.S. forces can see the battlefield by the time new systems now being designed are fielded (roughly 2008)?
- What are reasonable expectations of what the other side can see by then?
- How could the U.S. military best exploit DBK?
- How do these conclusions fare in the face of selected sensitivity analyses: a larger battlespace, a defensive orientation (notably U.S. troops in place at the outset of conflict), and an enemy whose strategy takes our information dominance technologies into account?

The usual caveat applies. Notional analysis cannot always capture the effect of technological surprise, and operational innovation. The course of any given conflict, in turn, depends on the identity of the foe (e.g., wealth, size, sophistication, and extant information infrastructure), whether our allies or enemies own the turf at the outset, the terrain of the battlespace (e.g., relative ratios of blue water, brown water, desert, plains, forest, cities, and jungle), the strategies of both sides of the conflict, and the rules of engagement that they, but particularly we, operate under—and, of course, circumstance and fate.

How Much Battlefield Awareness?

As computer, communications, and associated sensor technologies improve in power, speed, and acuity, the ability to see everything within a given area continues to improve, in some cases, at very fast rates. If it improves enough, even perfect situational awareness may *understate* what U.S. forces can see. Situational awareness is knowing the disposition, location, and orientation of all hostile forces—e.g., seeing the tank columns. Such knowledge permits more effective mission planning, prevents being surprised, and permits imposing surprise on others. What is more militarily useful is the ability to see a target precisely enough to ascertain its location within the lethal radius of whatever munitions best kills it—seeing each tank precisely enough to order its destruction by coordinates. Implicit in this definition is information dominance, so that U.S. forces can see deeply without themselves being at high risk.

A good sense of the possible results from four factors:

- How visibility is sought
- What its limits are
- What we can see
- What the other side can see in comparison.

What Our Technology Permits

A discussion of *how* U.S. forces achieve DBK: helps explain why the limits of visibility are where they are, how the architecture of a system that would ensure visibility has to evolve, and what opportunities lie for the other side to evade our sight. Collection, itself, is only the start of visibility (synthesis—data fusion—and analysis are equally

necessary), but it does set the limits of our capabilities and the requirements for integration software.

U.S. forces will be able to exploit a great number of sensors. Stand-off sensors can detect electro-optical, infrared, passive microwave, and reflected real or synthetic aperture radar. Close-in sensors can detect pressure, magnetic fields, gravity differentials, sounds, and certain chemicals.

Stand-off Sensors: Space sensors on heavy low-earth orbit (LEO) craft are likely to improve in resolution but still face tradeoffs among field of view, timeliness, and data transfer rates. Yet, today's technology also permits real-time coverage via staring sensors down to two meter resolution (e.g., via four Hubble-caliber spacecraft in middle-earth orbits). If sensor packages can be sufficiently reduced, a far larger fleet of very small satellites (e.g., the size of the $50 million MSTI or the $80 million Clementine satellite) can provide comparable coverage and much wider synoptic range. Fleets of small stealthy satellites are more robust against sophisticated foes with laser-blinding capability and other anti-satellite techniques.

If the locus of interest can be narrowed enough, unmanned aerial vehicles (UAVs), despite their weight limitations, can provide even better coverage than spacecraft; they can also fly under clouds. A UAV with a relatively light and inexpensive package (e.g., a 1000mm mirror-lens camera feeding a 2000 x 3000 charge-coupled device on a 35mm frame) can resolve down to 1cm from a kilometer away; a second camera placed 2m away from the first (e.g., on either wing, or one at the front and one at the back) can provide depth perception down to 1 meter (infrared sensors can work at night and detect heat signatures and synthetic

aperture radar is useful, but resolving power is usually only half as good). The UAV's problem is supporting real-time communications without revealing itself. Even without real-time communications, turning lidar (light detection and ranging) on, which helps find otherwise stealthy targets, can itself reveal a UAV's location to a sufficiently sophisticated enemy.

Active radar-based sensors can cut through most foliage and under the right soil conditions can see into the ground. They do so, however, at greater cost, with somewhat lower resolution, and being active, again, at the expense of platform stealth.

Passive sensors can also detect radio emitters and thus could geolocate their source. A technologically competent foe can nullify such information by using focussed transmissions (e.g., line-of-sight or at least microwave), generating electro-magnetic clutter, operating in a dense environment (one that produces echoes), or designing systems such that emitters are separated from more valuable targets (e.g., bistatic radars and relays to higher-power transmitters). Sooner rather than later the use of public-key encryption and digital signatures will limit our ability to exploit (other than detect) such radio-frequency or any other communications.

Close-In Sensors: These are good for supplementary information, making fine distinctions, defeating certain forms of stealth, and cuing long-range sensors. Any sensor that can fly can also be put on the ground; coverage is less, but resolution is better, and a collection of cheap devices can collectively produce powerful data.

Vibration sensors such as acoustic, seismic or pressure, particularly when placed in media such as ground or water,

can sense reports of artillery or gunfire and detect the movement of large machines. Antinoise devices (those that generate an acoustic signal equal and opposite of the original signal) may limit their future effectiveness.

Gravimetric and magnetic sensors are good for distinguishing otherwise identical vehicles by their weight or steel content. They are relatively hard to spoof (although magnetic fields can be cluttered), but their coverage is relatively small and they have to be placed near their quarry.

Chemical sensors, despite their limited range, are good for distinguishing among similar industrial activities, and for detecting the presence and movement of large mammals.

The Extent of Visibility

The value of DBK depends on who we are trying to see. Visibility is easier against likely enemies over the next 10 years, such as Iraq or North Korea, who are deeply schooled in the Soviet way of war but are less familiar with the information revolution. If future foes appreciate what our systems can do they may develop new forms of warfare to counter them. Industrial war can be beaten by informational tools; post-industrial war (which acquires many of its techniques from pre-industrial conflicts) is a far different challenge, as a discussion of the following limitations—bandwidth, intent, and denial—suggests.

Bandwidth: The raw data required to resolve down to even 0.1 meter over such a large terrain are daunting, even with tomorrow's computers. A single eight-band multispectral eight-bit deep image of a 200nm by 200nm box at 0.1 meter resolution requires almost a hundred trillion bytes of

information (e.g., 20,000 CD-ROMs worth even with low-loss 10:1 image compression or as much as NASA's Earth Observation System takes 2 days to produce). Real-time updates requires retransmission anytime something moves. Advances in processing speed and storage notwithstanding, the communications bandwidth necessary to transmit these data to an external processor for analysis runs into fundamental limits on radio spectrum (over-the-air laser-based communications may be necessary for such purposes).

U.S. forces will have to rely on cue-filter-pinpoint systems aboard sensors to report back on the battlespace selectively. Several laboratories are working on techniques that can pre-filter imagery by several criteria: e.g., industrial-age weaponry presents contours (e.g., straight lines) of the sort that are unlikely to occur in nature. Artificial intelligence will replace many human functions in recognizing objects and patterns, but a good system will have to be very large and the fate of complex and demanding software projects is always difficult to predict.

Intent: To what extent does seeing constitute knowledge? In a high or mid-intensity conflict against an adversary such as Iraq or North Korea, this is not a serious problem. The presence of a tank where it is not supposed to be is sufficient to infer intent. In this case, detection of the target, coupled with the appropriate strike systems, is all we need to destroy the target. Detection is only part of the challenge in dealing with guerrillas and terrorists, however. Being able to detect a pickup truck from a stand-off distance is no mean feat; knowing that its occupants might be armed and hostile, however, is prerequisite to forming a military response. Some data, such as the identity of individuals (useful in distinguishing threats from bystanders), or their facial expressions and body language (which might indicate

their intent) cannot be discerned by any remotely plausible sensor scaled for wide area coverage.

Broader data on the intentions of threats are likely to require humint. Such collection will be made easier by the information revolution (e.g., more detailed data bases on individuals, encrypted untraceable communications from behind-the-lines sources). Still, the fundamental determinants of such information flow (e.g., agent recruitment) are unlikely to change much over time.

Denial: Information collection capabilities are likely to outpace the parallel rise in the amount of clutter and the sophistication of stealth, but the latter will retard the onset of perfect visibility.

As the other side begins to see better (and shoot farther), the use of some of our sensors may be constrained. AWACS and JSTARS are wonderful tools, but they radiate like Christmas trees and will be at increased risk as the consequences of their visibility are made actionable.

How visibility is sought also matters. If we have the cooperation of those who occupy the battlespace, we can use infrastructure sensors. If we lack cooperation but our engagement is overt, we can dispense sensors into the environment. If our engagement is covert (e.g., we are not yet at war, or we wish to hide our fingerprints while helping one side of a conflict), U.S. forces cannot easily use sensors that can be captured and traced back us.

What Can We See?

Relying on cuing, filtering, and pinpointing makes systems vulnerable to surprise because certain scanning possibilities

are pre-excluded (the Inchon landing, the Nazis in Ardennes) or given short shrift (so that unexpected detail is treated as an anomalous artifact and ignored). Techniques can be developed to use systems of in-place sensors that can communicate among themselves, sift through their bitstreams, report only interesting data, and thus get around the bandwidth problem and limit the need for heavy manning of cue-filter-pinpoint loops. In practice, DBK will vary by target:

- U.S. forces should be able to detect the presence and movement of large platforms inside the 200nm by 200nm box in real time.

- When cued, our systems should be able to do gross identifications (e.g., distinguish Naval vessels from commercial ships). Large platforms include ships, widebodied aircraft, probably large SCUD launchers, tanks and armored personnel carriers (unless well concealed). When cued, U.S. forces should be able to determine the location and rough identification of military events such as small platform movement, missile firings, artillery rounds, and even most gunfire in real time and with sufficient accuracy for counter-fire.

- Most forms of stealth are not likely to work against U.S. sensor systems except perhaps stealthy missiles, which have short flight times.

- Many opposing sensors, particularly passive ones, are not likely to be seen by U.S. forces. Similarly, weapons that silently await signals before activation are unlikely to be detected if they are sufficiently small or indistinguishable from background objects

and if they are not concentrated in expected locations (e.g., non-metallic mines in straits or passes).

Finer gradations depend on the rules of engagement that govern U.S. forces (and allies). For instance, distinguishing a hostile infantryman from a civilian (friends can carry personal IFF devices) is not likely to be something a sensor can do. In a free-fire zone (or an environment where human activity is normally absent) it suffices to distinguish humans or civilian vehicles from their background; further distinctions are less important.

If military and commercial systems must be differentiated from each other before targeting, certain pieces of evidence can be used: weight, magnetic flux, radio frequency or chemical emissions, or even habits and tracks. However, a competent well-commanded enemy can be expected to mask all these features as best as possible. Forcing them to mask their signatures, however, has certain benefits; it further complicates their military operations whose normal coordination problems are already the source of much of the fog of war.

How much better vision can U.S. forces expect one or two decades compared to what it could do in the Gulf War? In many ways this is an unfair question. U.S. forces then benefitted not only from 6 months of preparation and a terrain with little natural cover, but also faced an enemy with little capability to use movement in its defense. Just prior to ground combat, U.S. forces were able to identify, locate, and destroy almost all relevant conventional infrastructure targets, including major emitters, roughly half of the tanks and artillery pieces, a disappointing percentage of nuclear facilities, and precious few SCUD launchers. Better tactical intelligence (particularly if the technologies

used in ARPA's War Breaker program proves out) would probably have raised real-time sightings of SCUDS greatly, moving targets considerably, and passive stationary targets modestly. Plausible advances in target detection between 1991 and 2008 are likely to make a larger difference under circumstances that frustrate visibility today (e.g., a moving enemy, little or no preparation time, and well-covered terrain), but which should yield to tomorrow's techniques.

What Can Others See?

Over 20 years we will see more, but we will also be seen more frequently. The latter may in fact, have a greater impact on how we conduct military operations. Our vision will permit more stand-off operations; their vision may well make it necessary.

Most middle- and upper-income countries should be able to pick up navigational signals from multiple sources (and map them into fine-grain digital cartographic data-bases), obtain satellite imagery at the 4- to 20-meter resolution level (from third-party purveyors or even their own small satellites), send signals on communications satellites (in low, geosynchronous, and even middle earth orbits), acquire sophisticated turn-key traffic management systems, operate UAVs with digital sensors and downlinks, and run police networks armed with networked minicameras. They could do this through buying or renting capacity from commercial markets or friendly governments.

Compared to likely opponents in a major regional contingency, U.S. forces are likely to have better information systems, a greater ability to degrade opposing information systems and conduct counter-space operations, and more access to stealth.

If the U.S. were to operate under more restrictive rules of engagement than our enemy, we could face a tough decision when it came to degrading enemy information systems or the enemy's access to third party information systems if doing so affects the assets of neutral or allied countries. For instance, we might suspect that our opponents are getting valuable data from ostensibly environmental satellites (which can resolve down to 20 meters) but unless we have proof that the owners are knowingly complicit in that transfer, it would take a hard decision from senior levels of our national command authority to take action against such assets. Similarly, the other side may be using a low-earth communications system like Iridium, but it may be difficult to design a jamming footprint without leaking interference into adjacent but uninvolved countries.

Implications

Troops given perfect visibility, or anything close, need no longer expend the effort and risk necessary to acquire it themselves. True, some of the effort is offset by work required to achieve DBK in the first place, but to the extent that DBK can be provided by stand-off systems or unmanned sensors, the savings in risk will be quite large.

This is no small change in how militaries, particularly armies, operate. Consider for example, what a large fraction of the Army's efforts and casualties during the Vietnam conflict stemmed from its search-and-destroy missions. The key word in that phrase is search; in many cases air power or artillery did the destroying. This reflected the reality that finding the enemy without troops on the ground in that environment was extremely difficult. Even in the Gulf War, one of the primary purposes of land forces was to smoke

out the other side; air power had destroyed as many tanks as it could cost-effectively and in a timely way. It took rolling metal to bring the Army's eyes to where they could see the rest of the enemy's tanks, forcing them to fire, surrender, or run. With DBK, only psychological reasons (i.e., the visibility of awesome power to make others stop hiding and either give up or run) remain to justify most classical ground operations except for territorial occupation. More generally, patrol operations of all sorts (from combat air patrol to frigate-based picket duty) and their attendant risks can be sharply cut back. Direct cost and casualty savings are supplemented by the indirect benefits of not having to support a large in-theater logistics and command apparatus.

The savings in logistics is more than money; our long logistics tail is our Achilles' heel. If Saddam Hussein had possessed more accurate missiles, his sallies would have created enormous havoc to our port operations. The next foe is unlikely to permit U.S. forces to build up without contest. The instruments of logistics—ships, ports, aircraft, airfields, and supply dumps—are far too visible to escape notice. Thus, with the exception of the stealthy equipment and doctrine attendant to the supply of special operations force elements, *any* logistics infrastructure will invite the attention of foes who cannot pass up an opportunity to extract cost and casualties.

DBK may also affect the order in which targets are attacked. To understand why requires first realizing that PGMs mean that what can be seen can reliably be killed. To the extent that the name of the game in future conventional warfare is to avoid being seen, successful militaries will base their strategies on operations that generate the least signature. Increasingly (especially in quick-reaction environments), movement is more likely to

generate signature than standing still. Movement expends energy, creates noise, disturbs the background, and shows up on moving-target indicators. Standing still has fewer signature disadvantages (evidence of human occupation in one place tends to accumulate, but such data take longer to collect).

Needless to add, offense in pursuit of territorial occupation is difficult to do without a great deal of movement. Thus offensive operations capture the initiative at the expense of greater visibility. As precision munitions proliferate and visibility, overall, increases, the initiative shifts. Mobile targets become more visible and the side with DBK has richer menu from which to choose. Thus the pattern of engagement can favor the DBK-rich side; initiative need not rest with the side with the greater firepower.

As the visibility continues to increase, the means by which targets are attacked assumes importance. The combination of our ability to see without being there and of the growing risks to our being there suggests three modes of engaging threat forces: via stand-off, using vertical coalitions, and with information warfare.

Stand-off Weapons Delivery

Weapons can be delivered from stand-off range via cruise missiles, and ballistic missiles, or, speculatively, laser (or other directed energy sources) from space. In the sense that stealth aircraft can transit a battlefield with reduced risk, it is essentially a stand-off weapon.

All these methods are expensive in ways that advances in information technology cannot do much to reduce. Cruise missiles from stand-off range require perhaps a half an hour

to engage a target. Versions with today's guidance systems (future GPS/INS guidance could be cheaper) cost around a million dollars and are vulnerable to look-down, shoot-down systems. Shooting within 1,000 or 2,000 km of a the target puts shooters at some but not much risk (submarines are stealthy but expensive cruise missile platforms). Finally, warheads are only so large.

Ballistic missiles permit faster turnaround between sightings and prosecution (an extended ATACMS could cover 200 km in 3 minutes). They can be fired from indefinite stand-off distances, and, in some versions, have the highest likelihood of hitting the target. They, too, will be expensive ($20,000/kg at least for indefinite range) until and unless reusable launch vehicles prove out. One variant on ballistic missiles is very long-range artillery delivered from electromagnetic rail guns (provided that guidance and control elements are engineered to withstand the initial G-forces generated on firing). Another variant is to use a large and very heavily armored sea-based platform as a host for long-range artillery or missiles.

Remotely controlled ground-based missiles offer the advantage of rapid delivery from short distances and can thus service short-term targets. Their use, however, requires either initial control of the terrain or some surreptitious method of delivering and emplacing these weapons.

A speculative way of engaging ground systems is through lasers from space (possibly space-based but more likely ground-based reflected off space-based mirrors). Lasers have the advantage of near-instant response, but they may infringe on treaties, and several tricky engineering problems remain to be solved. The location of ground-based lasers would be impossible to hide. Enemy targets, for their part, can be protected with obscurants and mirrors of their own.

Stealth aircraft permit multiple strikes with less expensive rounds. Yet, the F-117A is a $50 million aircraft that, even if flown twice a day (and preserving stealth requires heavy maintenance after each mission), can deliver only four bombs on target in that time period. Unless they are loitering, aircraft cannot prosecute targets that disappear a half hour after they appear (e.g., most aircraft, shoot-and-scoot systems). Moreover, stealth is designed for night operations.

Essentially, stand-off systems are worthwhile for large, fixed targets and expensive platforms that, once exposed, stay exposed for long periods of time. They are less than satisfactory for inexpensive targets, those generating short-lived signatures, or those that are exposed briefly (e.g., between hiding).

In general, the United States has already gone about as far as it ought to in replacing dumb rounds with smart ones wherever the latter are more expensive to use. For some targets, such as sprawling logistics sites or advancing dismounted forces, dumb rounds remain the appropriate choice of munitions. Prosecuting them with PGMs or long-range dumb rockets is costly and largely ineffective. Instead, U.S. forces need to maintain survivable in-theater systems capable of delivering dumb ordnance efficiently. A reasonable guess is that keeping our non-stealthy bombers hidden will require the ability to target enemy radars coupled with the other side's slowness in engineering bistatic radars and alternative sensing devices (e.g., acoustic detection). Keeping our own artillery hidden will be a contest between our operational stealth and their sensors, to include UAVs.

Vertical Coalitions

More often than not U.S. forces will fight in coalitions; historically, the most common types have linked U.S. expeditionary forces and the forces of a beleaguered ally. These coalitions have had both horizontal components (two brigades in combined operations) and vertical components (the United States provides the predominant amount of air power, while local forces provide more ground troops).

Our eyesight will permit future coalitions to be far more vertical, which is more than just as well in the absence of future great power conflict that would otherwise justify putting large U.S. forces at risk. The essence of a vertical coalition is that local allies would supply the forces and the firepower; the U.S. military would supply the information that would permit them to use smart munitions to approach near-perfect kill probabilities. The United States could outfit its allies's missiles with seeker heads whose software could help the missile home in on targets based on encrypted signals generated from information that we supply externally. Thus, unlike the Stinger missiles we provided to the Afghan rebels, such instruments could be made useless by turning off the targeting information; this limits the damage of their ending up in the wrong hands. We would supply overall intelligence on the whereabouts and movements of distant echelons. Our overhead systems (both space and air breathing) would permit pinpointing of enemy platforms. Our distributed sensor systems would be put in place to operate, analyze, and convert data into fire-control solutions. We might even control the targeting once they have fielded the weapon.

Vertical coalitions provide many advantages over horizontal ones. By reducing the number of U.S. forces at risk (special operators, significantly, aside), we would have far more

flexibility to intervene at lower thresholds before little problems become big ones (not to mention to test our information-based warfare systems more frequently and against a wider range of opposition). By removing our forces from the theater, we deprive smaller opponents of rallying points, and larger opponents of targets against which they might use weapons of mass destruction. Reducing the need to move forces long distances economizes our requirement for scarce and expensive power projection forces. In some cases, the United States might be able to tilt the contest to one side without unambiguous proof that we had intervened at all. The use of stand-off sensors as a substitute for forces also frees us from the necessity of overseas bases; they permit more operations to be planned and conducted from international waters.

That said, vertical coalitions are no panacea. In operations where we lack allies (*Just Cause*) there are no forces to multiply but our own. In *Desert Storm* a very high level of multiplication would have been required to permit Kuwait and Saudi Arabia alone to equal Iraq. Vertical coalitions require more intensive information exchange than horizontal coalitions and thus more difficult C^4I (as well as operational security) problems. Fuzing data from our stand-off systems, for instance, and any sensors provided by allies presents a large systems integration problem that we and they might not have a chance to practice beforehand.

Information Warfare

The more we know about the other side, the more economical our strikes against it can be; if we can paralyze the head—a strategy that entails command-and-control warfare—we need not take on the arms. Alternatively, if our forces knew exactly where enemy electronics sat, we

could disable them through a variety of soft kill methods (the difficulties of battle damage assessment aside). The result would be less bloodshed all around and, presumably, an easier time persuading the other side to come to terms.

Unfortunately, a large share of the information necessary for such warfare is not available from the usual sensors—it takes humint, a commodity whose supply not likely to grow at rates that characterize information technologies in general. True, analyses of radio-electronic emissions or network traffic statistics might shed light on how the other side's information systems work, but technology also provides ways for the other side to disperse command centers, encrypt communications, and otherwise confuse electronic collection by propagating electronic clutter.

Tomorrow's communications environment, however, offers a novel means by which information warfare could disarm foes with far less bloodshed. In the Gulf War's latter stages we were able to persuade Iraqis to flee their tanks by convincing them they all were targets. Using this template, suppose U.S. forces broadcast the identity and location of platforms and then destroyed them. After the correlation between having one's coordinates being broadcast and being destroyed has been sufficiently demonstrated, it may be enough simply to broadcast the identity and location of every found target; those who read their death warrant on the tube could be persuaded to abandon their vehicles, saving their blood and our weaponry.

Peace Enforcement

There is little doubt that technology can substitute for human intervention in enforcing peace, particularly in demilitarized zones to be denied for use as invasion corridors. In support of the Sinai accord, a U.S. defense

contractor used a sequence of sensors to monitor the Egyptian-Israeli frontier.

Visibility gives peace operations a new dimension beyond indications and warnings (that is, beyond situational awareness). Visibility allows the near instantaneous conversion of platforms to targets. Hitherto, violators across an observed zone lost a few minutes, or at most, hours of surprise. Visibility strips them of cover and leaves them vulnerable to precision-guided munitions; it links presence to certain visibility as the PGM revolution linked visibility to certain death.

More generally, such data permit both sides to speak from a single core image of the zone (even if one or both sides supplements it with their own sensors). If disputes arise, they at least do so from a common base of evidence and are that much more resolvable. Making imagery sufficiently detailed and providing all of it as collected deflects criticism that the provider (the United States) is presenting an outdated or even selective view of the zone to make a point.

One drawback is that our fielding our best stuff shows everyone the acuity of our systems. Conversely, by then, our edge may no longer be in sensors, but in pattern recognition and data fusion. We can show people what we can make out, but leave unsaid what we can in fact see.

Sensitivity Analyses

Most of the above analysis is robust against changes in two assumptions—the size of the battlespace and a defensive orientation—but a sophisticated enemy that alters its

strategy by assuming that we can see everything can limit what our DBK buys us.

Expanding the Box

Technically speaking, a larger box increases the bandwidth and assets required to achieve the same level of visibility. If the other side's visibility increases correspondingly, U.S. forces must operate from further away.

The most frequent critique of the 200-nm limitation is that, while it covers the tactical theater (e.g., the KTO, the central Korean peninsula, Bosnia), it tends to leave out the center of gravity for the other side (e.g., Baghdad, Pyongyang, and Belgrade). Yet the kind of visibility that technology (as opposed to better humint and analysis) affords over the next 20 years is unlikely to affect the strategic bombing campaign very much. The targets we could not find (e.g., nuclear facilities) were those we could see but not identify. Everything else (e.g., headquarters buildings, power infrastructure, power grids and factories) is already visible.

The more interesting question is an expansion of a virtual visibility unlimited by distance, or the ability to understand the other side's information architecture and the enemy's ability to target ours. This issue breeds optimists and pessimists. On the one hand, increased networking allows remote mischief makers to play havoc with U.S. systems. On the other, technology permits such systems to be made invulnerable in ways that, for instance, a tank cannot be made invulnerable. Today's gaps in U.S. systems stem from complacency, not technology. For instance, the 1994 hacker attack on Rome Air Development Center exploited a design flaw in the same Unix program that hosted the 1988 Internet Worm incident. As for attacking overseas systems,

the United States has many people capable of understanding how computers are wired and few people who understand how societies are wired into computers—as an example, who can explain why Japan has few internets? Knowing the value, to the enemy, of what we can destroy goes beyond identification of the target system.

Defensive Orientation

Visibility alters many of the differences between being on the offensive and being on the defensive. Traditionally, the offense could better concentrate firepower at a time and place of its own choosing. Visibility plus stand-off systems, however, largely nullifies that capability; force concentration is no longer a prerequisite to fire concentration. Usually the offense has the power of surprise and shock, but again, DBK should minimize the confusion (if not the fear) that gives surprise and shock its power.

Correspondingly, however, vision gives the defense two strong advantages. Whoever owns the terrain at the outset of conflict is in a better position to have the terrain wired for sensors, local positioning systems, and communications. Also, as noted, movement creates signature.

What if U.S. forces started with troops already in theater and forced to defend themselves? The oft-cited problems of confusing our forces and those of the other side in close engagements can be countered by IFF systems that rely on continuous and automatic positional reporting. Since troops in place mean some supplies in place, the problem of running supplies into theater is at least partially solved. The real problem is more likely to be political; our forces might be inhibited from shifting from close-in combat to stand-off

combat (much less to vertical coalitions) by the fear that our allies might be demoralized by the process.

Adaptations by the Other Side

It remains quite plausible that U.S. forces could detect, track, identify, and target every specifically military hostile platform (and/or vehicle) in the box fast enough to destroy it with precision-guided munitions. Demonstration of that capability would logically make nations abjure the use of industrial-era methods to coerce or occupy other nations. This is not tantamount to the end of military aggression, although, in itself, it is a significant achievement.

The largest gap in awareness would be the persistent difficulty of distinguishing military from their civilian counterparts in commercial practice. A pickup or jeep, for instance, might be far less effective than a tank, but if the Bushmaster or portable missile system inside it can be sufficiently obscured, such vehicles can still be potent against police or lightly armed military forces. Urban warfare would still be extremely difficult to sort out cleanly. With work, passenger airliners can be modified to carry weapons, and cargo ships can carry torpedo and vertical launch systems without a great signature.

Thus even foes who would resort to war for conventional ends (the control of other people and territory) might seek unconventional methods of doing so. The trick in employing such substitutions is to mask indicators of military activity. Such a shift requires both different operations as well as different equipment. A pickup truck may appear to be a civilian item but a coordinated charge of pickups across a desert toward a fortified point tends to resemble a charge of tanks more than it resembles normal commerce (or even summer weekends in the California

deserts). A fleet of 18-wheelers overwhelming a border guard would be assumed to be a military attack despite its bizarre guise.

A nation wishing to bring military force to bear on another would therefore be forced to adopt methods associated with low-intensity warfare:

- Infiltration of troops disguised as normal commercial traffic
- Encouragement of externally organized crime and terrorism by those otherwise assumed to be engaged in normal criminal activity
- Gathering of military intelligence using methods associated with commercial intelligence
- Exploitation of the target's own information collection systems
- Careful placement in advance of real bombs in a nation's physical infrastructure and logic bombs in its information infrastructure.

Such actions may induce tensions but not retaliation. At some propitious political point, the aggressor may burst forth using weapons of war that act military but until used, look civilian. Such methods may succeed without triggering the response that ostensibly military actions might take.

Military operations, in general, would gravitate to high-density environments despite their ability to slow forces of all kinds. Operations would be a constant search for cover and thus would favor forests, jungles, and cities. War would

seek commerce as its visual shield—an attack of jeeps otherwise hidden in everyday village trade, arriving at the proper point in time for an offensive operation, could be effective, although a high degree of skill in coordinating the attack may be required. River commerce can turn ugly quickly. Airports can be attacked by the precise discharge of armed troops emerging from the everyday chaos of air transport.

These actions make the pessimistic assumption that a target's immune system can normally and clearly distinguish invading antigens from its own cells. More frequently, the aggressor's task is eased by the continuous presence of elements in a friendly country, which for political or ethnic reasons might tolerate the political aims of another. Short of declaring large portions of itself a free fire zone, the defenses against such invasion are below the threshold that omniscience implies.

Nevertheless, if U.S. forces intervene in such chaos, its ability to see will be of value, but only in limited spheres. We may be able to detect and defeat local concentrations of force—as long as these points can be defined in time. However, forestalling smaller scale applications of force requires humint.

Compensatory Advantages

Nevertheless, if U.S. forces can blunt conventional military attacks, thereby forcing an aggressor to fall back on unconventional attacks, this is in itself a significant achievement. The force structure that is particularly efficient at coercing and conquering neighbors can be eaten whole by a U.S. military with dominant battlespace knowledge. A force structure that must operate through subtle but deadly means may be insufficient to exercise regional power and

seize and occupy territory. More generally, light forces that can evade U.S. systems are insufficient to outgun forces on the other side. The more that our ability to see forces a difficult choice between these two force structures, the better the chances for regional stability. A high-low punch makes it difficult for either light or heavy forces to survive. More generally, a nation might not be able to afford both types of forces; more tellingly, the command-control-and-culture necessary to support one method of warfighting may be completely incompatible with command-control-and-culture appropriate to the other.

A second great advantage, which follows from the first, is that unconventional aggression is more difficult to couple with coercion—which, in many cases, is the real goal. An Iraqi tank force, which had just taken Kuwait for lunch, may have the ostensible capability of coercing Saudi Arabia to conduct its oil marketing to Iraq's liking. If, however, Iraq had to rely on unconventional aggression to make the same point, its coercion would lose much of its psychological power. Since war is often used to give credibility to coercion, a capability resident in U.S. forces that removed coercion would reduce the likelihood of conflict.

The third great advantage, of particular importance as Asia replaces Europe as the cockpit of great power confrontation, is that the infiltration of forces across seas is far more visible than its infiltration across land. Simply put, in an increasingly transparent world, a seaborne threat is far less credible than a land-borne threat. Its best expression, a naval blockade, is never quick, resembles a siege in its visible side-effects, and requires a large and thus expensive blue-water submarine force (or very long-range rocket and missile bombardment) to carry off. Asian countries may be

ripe for rivalry, but without the physical means to convert this rivalry into successful warfare, such tensions are unlikely to be converted into crises that call forth a U.S. response.

Conclusions

U.S. forces can expect to enjoy dominant battlespace knowledge in major regional contingencies for the foreseeable future. The extent of such dominance will be limited by the persistence of clutter and stealth in tomorrow's environments, the vulnerability of information systems to semantic deception, and the enormous data-flow requirements (coupled with limited radio-electronic bandwidth) needed by synoptic systems. Cue-filter-pinpoint discrimination systems will ease this last problem, however.

U.S. possession of DBK would not by itself translate into assured victory under all circumstances. Our society is generally more sensitive to casualties, and our forces have to go farther to engage in battle. We also need to reduce our sizable logistics chain.

Investments that permit U.S. forces to approach full battlefield awareness reduce the effectiveness of (and thus deter) certain kinds of threats. The ability to combine stand-off and intrusive sensors to see most military platforms can force potential bullies to abandon the easiest paths to dominating their neighbors. Although second-best methods of causing havoc are certainly threats, they are harder and more expensive to employ and tend to work with far less certainty and speed. Thus, forcing others to resort to second-best methods can, to a large extent, decouple the deadly synergy between coercion and aggression.

U.S. forces are also becoming more visible; a fact that affects both how perfect visibility is achieved and exploited. Replacing large visible sensors by networks of smaller, less visible sensors permits omniscience to be preserved without our sensors being targets. Yet, the problem of getting steel on briefly visible targets from far away remains. Vertical coalitions, in which the U.S. supplies the eyes, and local allies the arms may be one solution to the riddle.

Does the criticality of DBK necessarily require we shift more of our defense resources to achieving it? In one sense, the tide of the information revolution is stronger than any swimming we do relative to it (even the cheapest desktop computer on the market today outperforms the top-of-the-line desktop of 1990). Otherwise, investment remains an issue of which rather than whether. The incremental value of some information investments (notably dispersed sensors, agile C^3, and data fusion) is still high while comparable investments in other technologies (e.g., fighter aircraft) may not offer the same advantages. However, some information investments may no longer be all that cost effective either (e.g., multimedia C^2 systems, and large complex sensors whether airborne, seaborne, or spaceborne).

As a broader issue, the military-technical revolution taking place within U.S. could also take place among those overseas. Its transformation into a revolution in military affairs with all that implies for operations, doctrine, and organization has yet to transpire, but the payoff is substantial.

THE SIGNIFICANCE OF DBK

Paul Bracken

The discussion of information warfare and warfare in the information age is often more confused and confusing than informative and productive. This may be true because the problem is hard to conceptualize, perhaps a testament to its ultimate importance. No analysts in history immediately comprehend the logic of their own situation in periods of transition; a long epoch of disorientation and confusion is usually necessary to learn the necessary rules of the new era. Observers of the contemporary period of military transformation are no exception. Perspectives and theories have to be broken in by the harsh reality of critical analysis in order to discipline them.

Standard models of military innovation neglect important parts of the story. Hitler backed Guderian's new Panzer tactics in the 1930s, but Hitler took a cosmic gamble that it is hard to conceive of a democracy taking. Napoleon represented the purist form of information warfare in history, yet he did this through organization of his army into corps and better intelligence, prior to any increase in information technology.

Approaching the problem from the top down makes it harder to understand how information technology affects military organization. General taxonomies, definitions, and classifications are created, refined, and modified in an exercise that too often is excessively abstract. Key details are stripped from the problem, details that should play a

larger role in shaping system design. Searching for better paradigms in order to design forces that exploit better information technology tends to be counterproductive, because it starts at too high a level of generality.

This chapter uses a bottom-up approach instead, as a counterbalance to analyses that refine high-level taxonomies. The fusion of the two approaches is discussed in terms of management issues at the end of the paper.

Two Canonical Scenarios

The significance of DBK is constructed from two important current contingencies: one from the Middle East, the other out of North Korea. The purpose is to draw out significant consequences resulting from improved battlefield awareness, not to fight the war or generate a scenario for its own sake.

Middle East Contingency

The October 1994 feint by Iraqi divisions toward the Kuwait border involved about 1,700 armored vehicles. What could we do with air power if we had the right munitions and knowledge of the location of the armored vehicles? With enough warning time to deploy 200 U.S. aircraft to the theater—combined land and sea based—and four antiarmor munitions per aircraft, at two sorties per day, and P_k of .5, *then up to 800 armored vehicles could have been killed on day one of the attack.*

This yields a vehicle attrition rate approaching 50 percent for a single day of combat, something that would have halted the Iraqi Army and thrown into disarray key units of Saddam's key institution of internal support, his Republican Guard forces. No ground force could maintain cohesion under this attrition. In reality, with tanks and APCs in

column, and the behavioral effects of killing lead vehicles, cohesion would break well before 800 vehicles were destroyed. What are some of the more important implications of having this capability?

- A substantial part of core Iraqi military capacities could have been destroyed in a single day. If this would not deter future adventures, it is hard to know what would. Among the many important factors, the increased efficiency of precision anti-armor munitions matters most.

- Against Iraq's feint, the U.S. deployed over 150 combat aircraft in a week. Thus, 200 aircraft is a large but not massive U.S. effort that could be deployed quickly, given suitable changes in logistics and preplanning. A smaller logistical footprint is extremely important. The often-heard comment that the United States had the luxury of a 7-month buildup before *Desert Storm* suggests that a quick reacting opponent could trump our response by beating our deployment times. Yet a 200-aircraft force with precision antiarmor munitions could do enormous damage even if an attack had commenced and the border been crossed.

- Sortie rates could be raised even further in the first days. Shifting carrier based planes from air defense to ground attack would have improved the results. Similarly, overloading the carriers, by adding an extra attack squadron to a carrier would increase capability kill further. In an Iraqi threat situation risks to the carriers would not be unmanageable. Moreover, other ways to protect carriers would permit more loading of

aircraft for ground attack to destroy more Iraqi vehicles.

- Using more air crews (or postponing maintenance) to raise sortie rate look attractive, because the tempo will not be maintained for more than a few days.

- The JCS concept of "flexible deterrent option" changes, from one where we worry about sending a force big enough to do the job, to one where a 200-plane force can halt a tank army.

- Iraq's most obvious counter is to attack air bases with SCUDs, possibly with weapons of mass destruction. Air defense of ground airfields increases in value, and the attractiveness of carriers also increases.

- Quick shooting real-time updates would be needed, for in reality the armored columns would disperse and flee the battle area.

- A fast deployable mine field, possibly wide area mines, dropped behind the armor could trap it in the forward position, or at least slow it down, leading to more kills. The traditional value of mines, to slow an enemy, has not had much historical effect because the fields were not covered by fire. Slowing an enemy in this new context clearly makes a big difference and could be a unique threat to force compliance with demilitarized zones.

- The law of requisite variety says that organizational structure should be only as complex as the complexity existing in the environment. The driver in this scenario is efficiency gain from an increase in weapon P_k's, something that was planned to occur by 1994. The

outcomes do not depend on any breakthroughs in sensors or computing technology beyond what is programmed to occur. Unless there is some reason to embrace additional complexity, it should be avoided.

Korean Contingency

North Korean mobilization would involve a sequence of actions: injection of covert special forces teams into the South, elite dispersal, the recall of ships to port, and a breakout of ammunition stocks to forward infantry and artillery. Two infantry corps and armored forces, consisting of some 2,500 tanks, 2,300 armored personnel carriers, 1,800 truck mounted multiple-rocket launchers, and 3,000 trucks, would move south. That plus artillery yields 15,000 high-value targets (armored vehicles, artillery, and ammunition and command centers), virtually all within the 200 nm square grid.

Compared to the Iraqi scenario, the North Korean one has a qualitatively different scale. Ten times more targets must be destroyed without delay to stop the assault before a breakthrough can take place.

The North Korean decision cycle in war is likely to diverge sharply from its preplan structure. Information flows, strategic variables, and institutional detail will be disrupted and swamped, because of the North Korean command system's inability to manage this scale of operation and by U.S. attacks on it. The really important North Korean communication system will not be the one from central headquarters to the field, but rather the one reflected in the behavior code of junior officers. There are six major north-south roads and effectively six invasion corridors. The ratio of vehicles to road space would create large traffic

jams, especially as it had never been rehearsed; large amounts of live ammunition would be handled and fired by untrained troops for the very first time; movement of chemical weapons would create special problems; the sparse command and control system would be flooded from below with reports of problems and requests for permission, leading to delays in new orders coming back from above; couriers would not be able to deliver messages in a timely way.

No one can say, in advance, where the traffic buildup will be greatest. With a U.S. ability to locate these areas quickly there is an impetus to decentralize the targeting assignments to cut down on delays. More precise tailored information may not be of great value in such a target rich environment and could be of negative value if it induced delay. There is relatively little danger that the North Koreans could quickly alter this condition, as their capacity to undertake cross-corps assignments of forces or to exploit the benefits from weapons of mass destruction is almost nonexistent, certainly compared to what was expected from the Warsaw Pact.

Because the United States would have order of battle and unit location information on North Korean units, our Marine amphibious forces could pose a much greater threat. This brings out an important feature of improved battlefield awareness: *knowing where the enemy isn't may be as important as knowing where he is*. U.S. forces could be injected into undefended areas and protected once they got there. The North Korean armored 10th and 425th corps are held back to protect the Pyongyang-Wonsan axis in fear of U.S. amphibious assault, something very much in our interest to maintain. In other words, battlefield awareness for the United States in Korea turns a combined arms attack at the DMZ into an infantry attack, as we can compel the

North Koreans to hold their armor back in order to send it to coastal areas to handle amphibious threats. This makes the defense at the DMZ more fault tolerant, as the pace of a breakthrough is reduced because of its infantry character.

The above suggests creation of U.S.-ROK *phantom divisions* to threaten North Korea all azimuth, in particular in the far north as well as on the Pyongyang-Wonsan line. The technical question is, how can we project an appearance of U.S.-ROK divisions at locations in North Korea that are undefended, but that would be threatening enough to require disruptive countermoves? This certainly requires DBK in the form of offensive electronic warfare, perceptions management, and special units.

Conceivably, with a preemptive strike on massing North Korean forces north of the DMZ a main line of resistance could be kept away from Seoul, with large positive political consequences. Flexible deterrent posturing alternatives become easier. One problem with surging U.S. aircraft into ROK airfields is that they become prime targets for weapons of mass destruction. Because these are fixed sites, the North Koreans could probably hit them. With improved battlefield awareness, basing offshore becomes feasible, as aircraft will not have to loiter searching on their own for targets. They can be sent to target rich areas immediately following launch. Improved battlefield awareness can lessen vulnerability to weapons of mass destruction of air assets. Nevertheless, U.S. ability to detect preparation for NBC attack by the North would still be extremely limited.

Impact of Improved Battlefield Awareness

With these two scenarios it is easier to think of the impact of improved battlefield awareness in more general terms,

starting from a perspective which is close to the action. Next, plausible improvements in this capacity in the year 2008 are incorporated. This involves substantially improved communication interlinks between sensors and weapons, greater interoperability among sensors, and operation of new high performance reconnaissance systems.

- Relatively smaller U.S. forces can be far more effective than anything previously considered. That a 200-airplane force could amputate a significant part of the Republican Guards and stop a four division attack in its tracks has major implications. The concept of a tripwire strategy can be altered, so that breaking a trip wire would immediately invoke prompt substantial punishment, not merely a threat of considered escalation.

- The debate over attacking fielded forces versus the enemy's brain would be reopened yet again. One of the reasons the *Desert Storm* air campaign took the form that it did was because during the buildup period, when the United States did not have Army defenders in place, it was not considered feasible to destroy an advancing Iraqi Army in Saudi Arabia. There is probably no answer to this debate, but *some shift toward striking fielded forces* is becoming a viable option.

- The *horizontal military organization* would be built around workflows and information flows which are lateral and cross departments (from national intelligence to shooters) without going up and down through a hierarchy.

- U.S. forces could operate with smaller logistical support, or more accurately, certain option packages could be structured in this way to reduce time and vulnerability. The role of the operations planner would change, from a *resource allocator* (e.g., assigning platforms to theater) to a *strategic assembler* (building a coherent organization from parts). Knowing what information flows to open up among sensors, weapons, and headquarters would require knowledge of work flows. This requires a different mind set and outlook, with significant training and exercise design implications. Opening Guardrail data flows to Navy forces or JSTARS to the Army would also depend on mission and threat and could not be prescribed in advance. U.S. forces *are* moving to a network organization, but it is a *variable topology network* whose structure changes by mission, threat, and condition.

- The United States still cannot afford to lose air bases. However, there are some mitigation approaches to compensate for this vulnerability. As logistics loads lighten, *aircraft and other launchers can be dispersed.* Reconfiguring aircraft carriers toward higher sortie generation (e.g. more air crews and more attack aircraft) is attractive, because of shorter periods of peak tempo operation.

- The threat environment is developing in a way that gives a large U.S. payoff to battlefield information dominance. First, many countries are changing from *mass infantry armies* to *more modern forces relying on armored vehicles and electronic command and control*, increasing the number of targets and emitters. Second, from the Middle East to Asia military forces

are moving from *division* to *corps* level structures because of their increased size. Both trends introduce not only new capabilities but also new coordination problems, which may not always be solved well. The next 20 years are likely to be a learning curve period for operation of more complex forces, and the United States can stay ahead of this power curve through increased battlefield awareness.

- Combat is increasingly assuming the pattern of a *continuous flow* rather than a sequence of moves and counter moves. Analogy with corporate experience suggests this calls for new organizational structures to manage operations, and that their character cannot be entirely foreseen.

- *NBC weapons* remain a major problem unlikely to be solved by any foreseeable improvements in sensors or weapons. Even a few successful attacks can cause large destruction, and the U.S. will not have a 100 percent counter to them.

- With more front-to-front horizontal information sharing, the importance of the nodes closest to the action become critical. The problem is not one of nodes failing (which could be countered by redundancy) but the *propagation* of faulty data from node to node (where added redundancy compounds the problem). Instead, it requires extensive cross-checking and filtering, driving up the information processing burden. Information technology may help more by its ability to compensate for the inevitable transmission of incorrect data in a network as for its support for more precise targeting.

Management Issues

What would an investment program to attain improved battlefield awareness look like? The current planning, programming, and budgeting system (PPBS) categories may be worse than useless; they reflect an era of fewer interdependencies within U.S. forces. The benefits of DBK arise from improved weapons *and* faster operations, which are not covered by PPBS categories. PPBS assumes a loosely coupled system where command and control investments can be neatly separated from weapon system decisions; with future forces, one part will influence the success of the other. A plausible replacement for the present PPBS, intended to reflect the unique character of battlefield awareness improvements, is suggested from trends in the corporate world.

A Business-Matrix Approach

How have large multinational corporations approached their reorganization to exploit information technologies? There are at least three important distinct success characteristics of these firms:

- Timely responsiveness
- Efficiency
- Knowledge transfer among their parts.

In a military setting timely responsiveness would be measured by decision cycle time, time lost awaiting decisions, percent deliveries on time, etc. Efficiency is measured by cost per kill, kill probability per weapon, the number of sorties per day, etc. Knowledge transfer is analogous to information availability and intelligence and is measured by the ability to connect sensors and weapons,

to interlink reconnaissance systems, and to check against faulty data.

A business-matrix approach involves scoring different forces on these three criteria against varying threat contingencies. The goal is to force consideration of the investment tradeoff among programs that reduce response time, increase efficiency, and exploit the synergy of these two through improved information and intelligence. Historically, the Pentagon has invested in building up programs that emphasize some of these more than others. During the McNamara years the emphasis was on efficiency. During the 1970s it was on responsiveness, of getting a force quickly to the Persian Gulf. Today there is a large investment in information and intelligence.

In the future, DOD will have to emphasize *all three characteristics*, with an operations staff that can assemble a force with dominant features best suited to a situation. In the Iraqi scenario, for example, it is the increased efficiency of laser-guided bombs reflected in higher P_k's that gives the decisive benefit. In the Korean contingency, responsiveness is critical because of the forward deployment of the North Korean Army.

The major management problem facing the Pentagon is focusing on *organizational metrics* rather than on *technical system characteristics*. Information technology enhances the contribution of specialized technical staffs, while the great benefits of interlinkage among shooters and sensors fosters the merger of such staffs to get the design right. That these specialists come from different technical communities creates friction and misunderstanding, which can distract attention from the larger purpose. The objective is the payoff from these changes, which should be judged not in

purely technical ways such as higher data rates, but rather in improvements in organizational performance such as increased responsiveness and efficiency.

As multinational corporate experience suggests, the *right* answer is not to decide in advance how much responsiveness or efficiency is needed, but instead to have an operating system that can adjust rapidly to different environments. For a Korean scenario, the U.S. military should tilt toward prompt responsiveness, while for the Iraqi scenario it is less important to get large amounts of force there than it is to get the right kinds of shooters and munitions. This is what is meant by *strategic assembly*, the art of tailoring the force to a contingency. Strategy to task assignments are no longer one-shot affairs, but continuous activities which change with conditions.

This heightens the importance of knowing the enemy, not just target signatures, but also his decision cycles and in institutional detail. Knowing about the training of North Korea's junior officers matters because its macroinformation structure will disintegrate when burdened by the coordination tasks of operations, especially when it is degraded by U.S. attack. The resulting microinformation structure at company level and below is what the North Korean Army will devolve toward. This phase change is important, but it is fairly certain that U.S. intelligence does not look at the problem this way. The new intelligence roles and missions commission should be brought into this discussion because U.S. intelligence organizations are at a critical time of transition.

Change Strategies

Most people probably believe that changing the organization for increased battlefield awareness is driven by changes in its formal structure, or at least by the rearrangement off information circuits in it. The classic organizational change strategy has these sequential steps:

- Change formal structure and responsibilities
- Change interpersonal relationships and information flows
- Change individual attitudes and mentalities.

But the ideas in this paper suggests a better change strategy would be *to reverse this order completely.*

The search for high-level general taxonomies (e.g. information warfare, counter-command and control warfare, offensive versus defensive information based warfare, and so forth) reflects a perspective on the problem that is a prelude to changes in formal departmental structure (e.g., the department of counter-command and control warfare, the department of defensive information based warfare). Understanding the enemy's microinformation structure, tradeoffs among responsiveness and efficiency, and a strategic assembly mentality all arise as the end product of changes introduced after boxes and lines are moved around an organization chart. This is quite troubling.

It would be far better to *begin* the analysis of what to do with the aforementioned end products, because this would greatly improve the chances off getting the design right in the first place. Then, formal structures could be built around

information and work flows, it would be organized around *process* rather than around *departments*.

All this goes to the problem of managing the synergy of information and intelligence with responsiveness and efficiency. The major problems of achieving dominant battlespace knowledge are *not* problems of departmentalization and coordination of operating forces, but rather *problems of organizing information storage and processing—not problems of a division of labor among services, but problems of the factorization of decisionmaking*. These problems are best attacked by examining the information system in abstraction from service and department structure.

THE FUTURE OF COMMAND AND CONTROL WITH DBK

David Alberts

The Vice Chairman of the Joint Chief of Staff has posed a deceptively simple question: How would we do things differently if we had DBK?

While the explosion of information and communications technologies has profoundly affected the basic structure and operations of some organizations, others, including DOD, have adapted in an incremental fashion. Yet to fully understand the implications that a vastly improved awareness of the situation could have on concepts of our defense posture—including operations, command structures, forces structures, doctrine, training, weapon systems, and logistics—we need to consider the possibility of revolutionary change and we need to build a mission-oriented DOD based on the opportunities afforded by technology—in this instance, the opportunities afforded by achieving DBK. To do this we need to explore one important aspect of this challenge; how we might capitalize on the opportunities made possible by having a vastly improved capability of situation awareness by changing the way we approach command and control (C^2).

This paper begins by laying out the terms of reference followed by an analysis of the overall impact that having this capability would have on U.S. Force Structure, Organization, and Doctrine and the role that C^2 plays in

determining these attributes of our defense posture. The historic role of C^2 in warfare is then sketched in terms of how it contributes to the achievement of the fundamental principles of warfare. The C^2 capabilities necessary to leverage fully these opportunities are then identified. Finally, the changes that need to be made to current approaches to command concepts, organizations, doctrine, and systems in order to exploit our improved knowledge of the situation are explored. The paper concludes that the potential benefits of achieving DBK are well worth pursuing and identifies a number of issues and action items to address and realize these benefits.

Terms of Reference and Assumptions

The impact that any improvement in our capabilities will have is a function of the particular mission and scenario at hand. As a baseline for the analysis, from which excursions in the form of sensitivity analyses can be taken, a Major Regional Contingency (MRC) with a regional power is considered. The horizon for the analysis is the year 2008. This is far enough out to achieve significant advances in capability as well to provide the time needed to adjust our doctrine and organization to take advantage of those advances.

The baseline case does not consider coalition warfare, which could significantly complicate C^2. In addition, this analysis initially focuses on a combat mission unencumbered by tight political constraints of the type that have limited our ability to act in Bosnia.

Situation awareness has many different dimensions, and while given the time horizon and the nature of the resources likely to be available, "total" or perfect situation awareness is beyond our reach. Nevertheless, improvements in our

capabilities well short of achieving total or perfect situation awareness could provide quantum improvements in our effectiveness. By 2008 we could achieve considerable improvements in our current ability to see and understand the battlefield. Our adversary, a regional power, will also be able to take advantage of some of the available technology, albeit not to the extent we will. Thus, the United States will continue to have "information dominance" in a notional 200 nm-square battlefield, maintaining or even increasing the edge we have over others. *Information* dominance, however, would be of only academic interest, if we could not turn this information dominance into *battlefield* dominance.

The ability to approach total situation awareness and prevent our adversaries from achieving it, and our capability to exploit our relative advantage in information result in a situation in which we have achieved DBK.

Achieving DBK without being able to respond militarily to an adversary's moves is a nonstarter, so this paper analyzes a situation in which the united States can strike at virtually any target or a kill-at-will capability and establish a virtual link between any sensor and any weapon in near real time—but not necessarily between all sensors and all weapons simultaneously. As with situation assessment, kill-at-will capability comes in varying degrees characterized mainly by P_k (the probability of kill) which in turn is a function of target latency and hardness, travel time or the amount of time it takes to put "ordnance" on target, and the accuracy of the delivery system. While post-kinetic weapons may reduce travel time to virtually zero and increase accuracy dramatically, significant delays associated with targeting and command decision processes associated with combat will remain. Thus, the tradeoffs between the

quality of decisions and speed (addressed later) will remain a central issue for C^2 for the foreseeable future.

As noted, situation awareness is multidimensional. It includes knowing the current position, classification, identity, condition, and recent history of all items of military significance on the battlefield (in the 200 nm square). It also can be said to include knowledge of the objectives, intentions, and plans of all players. Items of interest include "strategic" targets of both the conventional kind (e.g., factories) as well as the unconventional kind (e.g., financial networks). A baseline assumption for DBK is that we know, in near real time, the positions of all friendly, neutral, and enemy objects of interest; we have more limited information regarding their current conditions and recent histories; and we have somewhat less information about enemy intents and plans.

The information associated with DBK is assumed to be "corporate" knowledge—that is, we collectively have this information. It is not assumed that this information is instantaneously available to everyone. If fact, figuring out how best to distribute elements of available information is a major challenge and will, to a large extent, drive our approach to C^2.

Implicit in DBK and kill-at-will assumption is our possession of considerable stand off capability (for example, remotely piloted vehicles); few manned systems would be placed at risk. In fact, in the kind of warfare in which both sides have good situation assessment ability and relatively smart munitions, high value targets become extremely vulnerable unless this vulnerability is reduced by stealth or speed.

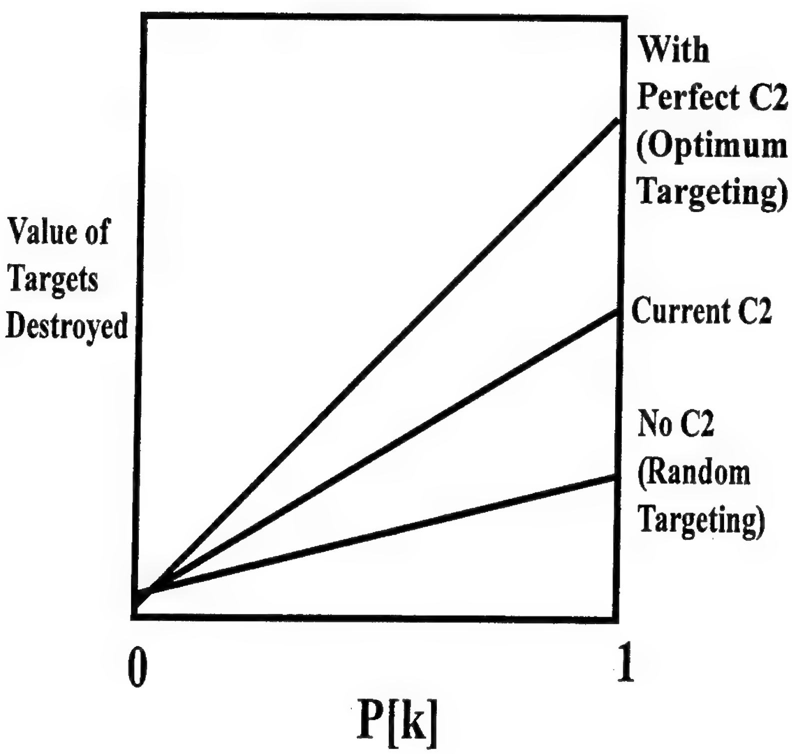
Finally, it is assumed that we are resource constrained. That is, weapons, logistics, communications, and computer processing are limited and need to be allocated and scheduled. In fact, in a very real sense, the problem boils down to resource allocation questions and our ability to make these investment decisions in ways that allow us to take full advantage of the opportunities that technology affords to defeat the enemy with minimum casualties, collateral damage, and time and resources expended.

Potential of DBK

A common analytical technique is to make some simplifying assumptions to "bound the problem" in an attempt to establish the feasibility of an approach or concept.

In this case, a gross feel for the potential value of DBK can be derived from looking at the problem of destroying a given number of targets with different levels of C^2 capability (figure 2). While the word *destroy* is used to simplify this discussion, it should be understood that in reality a full range of actions, including exploitation, co-option, disruption, and degradation need to be considered.

Figure 2
Potential Value of DBA



The worst case is when one has no C^2 and weapons are free to fire on any target. In this case, unintentional, duplicated, and/or overlapping fire will result. Some targets will be "over killed" while others will escape unharmed. Given no C^2 or what amounts to random targeting, there is also no ability to prioritize targets, which on the battlefield have widely differing values, values that change as the dynamics of the battle unfold. The values of targets are not limited to positive numbers; there are also numerous situations when targets may actually have negative values and thus need to be avoided rather than hit. Obvious cases include the sort of collateral damage that can be exploited for its propaganda value. Less obvious cases are situations in which killing a particular target sacrifices possible long-term benefits for short-term gains.

Given perfect C^2 (which in turn is dependent on perfect information), an optimal allocation of weapons assignments can be made dynamically as a function of ordnance available, weapon capabilities (P_ks), and target values. The result will be that high-value targets are destroyed with high probability; that valuable ordnance is not wasted on low value targets; and that targets with negative values are spared. The result will be that more operationally significant damage will be inflicted along with a more effective use of resources. The leverage of C^2 grows as the effective P_ks increase. Our current ability to do C^2 falls in between these two extremes, and the value of achieving DBK is bounded by the spread between the line that represents our current ability and the line that represents perfect C^2. The potential impact of DBK goes well beyond any tactical advantage associated with being able to destroy targets efficiently.

DBK, in providing us with an opportunity to hit the right targets at the right time, offers us an opportunity to change

the way we organize, command, and equip our forces. It is the impact associated with these changes that will determine the ultimate value of having DBK.

Figure 3 illustrates the fragility of overreliance on DBK or indeed C^2 at the expense of firepower. We be careful to build an organization with significant teeth, and if we choose to embark on a path that makes us heavily reliant on technology, we must also take steps to ensure that the systems that we will come to rely upon to give us DBK and C^2 are designed to deliver appropriately high levels of reliability and availability. We will also need to deal with the possibility of technology failures or degraded capability, however rare they are projected to be, to ensure the success of our missions. The safety blanket of having force in depth to hedge against failures in systems may not be a viable approach given current budgetary trends.

Investment Challenge

Determining the role that a vastly improvement situation assessment capability can play in our defense posture is a part of the perennial debate regarding the proper balance between investments in C^2 and other elements of our warfighting ability including manpower, readiness, high- and low-technology weapons, training, and education. Despite the growing consensus that additional investments in C^2 will pay off handsomely, beyond some point it will be more than offset by reductions in force structure or readiness.

Figure 3
Limits of Command and Control

A View of Future Command and Control

The remainder of this chapter develops a view of future C^2 that evolves from the achievement of DBK. DBK represents a quantum leap from even our current level of capability, which is nevertheless formidable by historical standards. Therefore, it would be incorrect to simply extrapolate linearly from today's capability. This approach would also lead to incremental change that will not get us to the point where we could fully exploit the opportunities afforded by DBK. Put in another way, business as usual is not the answer. Incremental changes will not result in greater effectiveness, speed, or efficiency. DBK provides an opportunity that can not be fully taken without turning to new command concepts and organizational approaches.

Given the assumptions used in this analysis, command control will undergo change in a number of key ways. Commanders will be more focused on strategic issues; the role of staffs will be diminished; and, organizations will be

flattened. New concepts of operations will be required to achieve the desired levels of target damage necessary for success and there will need to be associated changes in force structure, the mix of weapons, and the nature of logistics.

The reductions needed in response times (decision/execution cycle times) and the number of decisions that needed in high-intensity combat situations, all in a short time span, are beyond human capability. Fortunately, the changes brought about by DBK make automating a large subset of decisions a viable approach.

To follow the reasoning that led to these conclusions, we must start with a review of the objectives of C^2 and how, over the years, we have attempted to improve our ability to plan and conduct warfare.

C^2 Objectives

C^2 exists only to facilitate the accomplishment of a mission. Its has no intrinsic value, rather its value derives from the contribution that it makes to mission success. A brief review of what C^2 has traditionally sought to achieve and how it attempts to achieve it will provide a good foundation for understanding what will change with DBK.

C^2 provides commanders and their staffs with the tools necessary to successfully operate in an environment clouded by the fog of war and uncertainty. This environment of "fog" and of uncertainty has profoundly influenced military thought and strategy throughout history. The principles of war are rooted in this fundamental characteristic of the battlefield. Therefore, it should be of no surprise that the way the military is currently structured results, in large part, from a desire to minimize confusion and misunderstanding

and to deal with uncertainty. Unity of command and appropriate span of control involve structural approaches to the problem, while approaches to the development and management of information have been process oriented. While much progress has been made in improving the C^2 process, less attention has been focused on the structural or doctrinal aspects of C^2.

Specifically, C^2 and associated organizational structures, military tactics, procedures, and doctrine have sought to:

- Reduce the fog of war,
- Exercise control over forces in a way that accommodates the fog of war,
- Exploit the fog surrounding the enemy commander and forces, and
- Increase the fog for the enemy.

Given this way of looking at the objectives of C^2, it is clear that what has become known as "information war," or IW, is intimately related to C^2.

C^2 has sometimes been confused with communications or information systems, and IW has sometimes been confused with electronic countermeasures. These misunderstandings are obstacles to progress and need to be addressed, because achieving DBK requires an full understanding of C2 and IW.

Command, control, communications, and intelligence systems (C^3I) have been primarily concerned with reducing a commander's fog by attempting to provide a complete and accurate picture of the enemy and the environment, reports on the disposition and capability of friendly forces, and battle damage assessments. C^3I systems have also been

used to achieve timely and assured dissemination of information (and orders) and in achieving a common perception of both the situation and commands (missions, objectives, and tasks). With the addition of significant information processing power and decision aids, C3I systems have begun to support a capability for near real-time reassessment of the situation and continuous option development and analysis.

C^2 as an Offensive Weapon

While C^2 has long been considered an enabler necessary to help attain the goals contained in the often stated Principals of War, it has only been very recently that C^2 has been seen as an offensive weapon. The essence of the offensive nature of C2 derives from its contribution to maintaining the offensive in classic terms. Maintaining the offensive involves the ability to dictate both the time and place of action.

The offensive nature of IW has long been understood, for IW both utilizes friendly C^3I systems and targets enemy C^3I systems. One of the greatest potential benefits of DBK is, in fact, the improved ability it provides to conduct IW. The ability to neutralize, disrupt, subvert, deceive, weaken, or fragment an enemy's offensive or defensive capability by taking actions against enemy commanders, staffs, and systems translates into a powerful offensive capability. When combined with a strategy to achieve option dominance, IW and C^2 achieve their greatest synergism.

Option Dominance: The Ultimate Offensive Weapon

A key to achieving option dominance is being able to respond faster than one's adversary—to always be one step ahead. Such an ability will permit us to co-opt enemy

plans and actions before they can be effective. In order for us to achieve option dominance, three conditions or prerequisites must be met:

We must recognize what needs to be done. This involves a number of interrelated steps including the development of an understanding of the current situation and its implications, the generation of options to be considered, the analysis of these options, and a command decision regarding what option will be taken.Having recognized what needs to be done, we need the ability to accomplish all this faster that it takes for the enemy to act (or react). This involves not only all the tasks implicit in recognizing what needs to be done, but also the time it takes to translate an option into understandable assignments, their transmittal to subordinates, and the time it takes to understand these directives and act upon them. It is important to realize that absolute speed is not the issue, rather it is the relative speed that is important. Thus, we gain as much from slowing down the enemy as we do in speeding up our C^2. In fact, given the tradeoffs between absolute speed and quality, slowing down the enemy (via IW) carries with it some attractive benefits.We need to be more than a paper tiger. That is, we need the ability to actually execute the option selected.

Having DBK certainly is a very big part of recognizing what needs to be done. But by the same token it is not sufficient to achieve this first necessary step on the road to option dominance. Perhaps the most important missing ingredient is the need to develop an appropriate response to the situation as it is unfolding. This requires the creativity and insight that only an experienced commander can bring to the battlefield.

The very same technology necessary to achieve DBK, namely information and communications technologies, may make it possible for us to operate inside the enemy C^2 cycle. But the ability to push piles of data around the battlefield is not sufficient to allow us to operate inside the enemy's decision and execution cycle. We need to be able to design a more streamlined process than we currently have to satisfy the time-critical nature of this task. (This is considered a little later on). The kill-at-will capability assumed for the baseline analysis completes the picture and allows us to take advantage of the information dominance we have achieved.

If option dominance can be achieved, and we can demonstrate this capability to potential adversaries, then we may be able to preempt enemy actions and hence prevent this kind of extremely costly combat from occurring. In effect, we would effectively change the nature of conventional war.

C2 Implications

There are two major implications that the achievement of DBK has for our approach to C^2. The first is that we will effectively move from a situation in which we are preoccupied with reducing the fog of war to the extent possible and with designing approaches needed to accommodate any residual fog that exists to a situation in which we are preoccupied with optimizing a response to a particular situation.

In short, we will move from a situation in which decisionmaking takes place under "uncertainty" or in the presence of incomplete and erroneously information, to a situation in which decisions are make with near "perfect" information.

Decisionmaking in the absence of complete and accurate information is far more difficult than decisionmaking with perfect information. Therefore, many of the ways we approach command today are a direct result of finding ways to come to grips with the task of timely decisionmaking in the absence of adequate information, under conditions of extreme stress, and where the cost of error may be extremely high. Professional military education (PME), doctrine, and organizational structures have all been tailored to deal with this problem. The result is to concentrate on what is called minimax solutions, that is, on those focusing on avoiding decisions with large downsize risks in favor of decisions which are "optimal" by expected value standards.

There are other implications as well. These include an emphasis on strategy and tactics that require keeping considerable forces and resources held in reserve to deal with the unknown or unexpected. While DBK certainly does not eliminate risk or uncertainty from command decisionmaking, it does radically alter the balance of the situation. Accordingly, those command concepts, doctrine, organizations, and force structures that have been optimized over time to deal with the fog of war need to revisited to see how they might be better adapted to the realities of DBK.

The second major implication of having DBK derives from the conditions that must obtain if we are to be able to take full advantage of the opportunities provided by having this capability. The utility of having DBK is a function of both the timeliness of the response and our ability to make the most of limited resources. These two prerequisites for success frame the C^2 issues we need to address. At issue is the way we will distribute information and decision making. Without a doubt, we will need to finally break the umbilical

chord between the command chain and the flow of information.

The Key Tradeoff: Speed v. Optimization

DBK gives us the opportunity to hit movers, blunt offensives with "massed fire" rather than "massed forces," and achieve option dominance. The desire to take advantage of this opportunity provided by DBK drives us to minimizing the decision and execution cycle—going from seeing a target to destroying one. "Destroying" as used here includes physical destruction or "hard" kill as well as interruption, neutralization, and other aspects of "soft" kill.

Running counter to this need for speed is the need for optimal resource allocation. Resource allocation is needed to ensure that the fire power available during a given period of time is allocated to targets with the highest priority (value) at that time. Resource allocation is also necessary to keep the costs of supplies and lift capability as low as possible. Thus, the desire to get ordnance on target rapidly comes into conflict with this need to efficiently and effectively allocate resources. This translates into C^2 architectural tradeoffs.

To minimize the decision/execution cycle, the path from the sensor to the shooter needs to be minimized—if possible, to go directly from the sensor to the shooter. However, to make best utilization of resources, allocations needs to be made "globally", that is, over the entire battle space and in the context of an appropriate period of time. Thus, the decisionmaking process required to allocate resources needs to be able to "see the big picture" in order to determine overall priorities and the consequences of various allocations. Central to the future of C^2 will be the nature of

the tradeoffs made with respect to distributing information and decisionmaking.

The best way to distribute decisionmaking and information on the battlefield is, of course, a function of the mission, scenario, technical capabilities, and cost. However, we can be reasonably certain that, in the time frame for this analysis, that neither a completely centralized nor a completely distributed approach will be best. Why? First, providing DBK to all shooters would require prohibitively high bandwidth and hence cost. Second, hierarchical flows of information would be too slow to achieve the decision and execution cycle times necessary to maintain option dominance. Therefore, an inventive mix of horizontal and vertical information flows as well as a new approach to decision making will be required.

In terms of getting the right information to shooters in a timely fashion, the challenge will be to dynamically manage the flow of information from sensors to shooters along with targeting priorities and ROEs. This will involve a highly automated capability to establish virtual links (sessions) between selected sensors and weapons. These sessions would need to be dynamically managed in accordance with battle events and priorities. Here, again, a key tradeoff will need to be made; this time it boils down to a tradeoff between optimization with centralized control v. less than optimal allocations with distributed control.

Given the enormous complexity of the battlefield at the level of granularity of control needed for real-time targeting and prioritization, ways to effectively decompose a battlefield need to be explored. Creating what might be called "Information/Resource Spheres" seems to be a promising approach. The concept of decomposing the

battlefield into information/ resource spheres is designed to create manageable "areas" in which the distribution of information and decisions can be optimally distributed dynamically. These "areas" may not be solely geographically based. Each information/ resource sphere would contain all the information necessary for DBK within the sphere. Spheres would operate asynchronously. Forces within the sphere would need to be able to operate seamlessly, "organically joint" or integrated so that all communications, doctrine, and procedures worked together transparently. Each sphere needs a single commander who has command over all forces and resources necessary to counter the threat within the sphere. The creation of information/resource spheres is, in effect, a means to distribute workload in a way that tries to keep suboptimization to a minimum. Using these spheres requires, of course, that an overall commander create spheres, collapse spheres, assign missions, ROEs, priorities, and resources to spheres and monitor their progress and situations.

Impact of DBK on C2

As noted, DBK moves us into a world where many decisions can be made with something approaching perfect information. Not only are these decisions far easier for humans to handle quickly while under stress, but these types of decisions become more like mathematical problems that are truly a "piece of cake" for computers running sophisticated applications software to handle.

Computers do some things "better" than humans. Making "routine" decisions with near perfect information rapidly is one of those things. Given the very large number of decisions that will need to be made in near real time and the massive amounts of information that will need to be

processed to support these decisions, not only can computers do the job, but computers are the only way the job can be accomplished.

Rather than diminishing the role or importance of the commander, the delegation of these decisions to computers (really "expert systems" that have been designed and tested by military experts) actually frees up the commander to devoted more energy to strategic issues and concerns. As a result, commanders will be able to concentrate their efforts on establishing mission objectives and priorities and in balancing assignments and resources. Perhaps even more importantly, it frees commanders to devote attention to developing possible courses of action for consideration, a task that requires the creativity and experience that only they can bring to the battle.

The role of staffs will significantly diminish, however, provided that adequate processing power is available and appropriate expert systems have been developed and tested. Because many of the detailed tactical or logistical decisions will become automated, staffs will not be needed nearly to the extent they are now. There are some rather nice side effects to this consequence. First, the fog that is generated by staffs will be much reduced, and second, communications and processing resources utilized by staffs will also be reduced.

Edge of the Envelope C^2

While by 2008 we will not yet be able to fully exploit the opportunities that are provided by DBK, we will be considerably down the road toward that objective. The edge of the envelope of C^2—the C^2 that makes optimal use of DBK—while not achievable by 2008, is nevertheless

instructive to imagine, providing us with a vision of the direction in which we are headed. This vision will not only help to focus our attention in broad terms on where we are going but will also enable us to see if there are unintended consequences or dangers associated with taking this path that need to be worked.

DBK and the technology associated with the achievement of DBK will permit commanders to operate in the "Nintendo" style. With the view of the battlefield and resources literally at one's fingertips, a commander will be able to, at the click of a mouse, obtain different views of the battlespace (varying in their focus and granularity) in order to be able to develop an assessment of the situation and in turn develop options. The commander will be able to explore the likely outcomes of various options and, upon deciding on a particular course of action, to have the decision translated into appropriate orders and communicated to subordinates. If the tempo of the battlefield permits, or if the sensitivity or importance of a particular aspect of the conflict warrants the commander's personal attention, a commander would have the ability to manage at a micro level as well. The operational and tactical levels of command would therefore be compressed into one in the "command console" and the systems that support it. To support this edge of the envelope C^2, a number of automated capabilities would need to exist:

- Software that, given mission objectives and available resources, would prioritize targets;

- Algorithms that, based upon the attributes of targets and weapons, would assign targets to weapons and provide for the virtual link between sensor and shooter;

- Experts systems that could develop, in near real time, battle damage assessments;

- Planning tools that could allocate resources with total asset viability; and

- Software that could play out various options and determine and assess their outcomes.

A commander of the future would also be able to, with the help of automated decision aids, discompose the battle space into spheres that automatically parse mission assignments and objectives, as well as information and resources, in an appropriate fashion.

Summary of the Impact of DBK

Having DBK would have a dramatic impact on the way we approach C^2. The role of commanders would be enhanced in a number of ways:

- The importance of a strategic vision would increase simply because, given DBK, such a vision would be far more likely to be "right" and hence less effort would be spent on "adjusting plans" or "replanning."
- Commanders would have a much greater chance of having their vision correctly implemented given the automated processing and communications support provided.

- By freeing commanders from worrying about the fog of war and developing contingencies for a variety of different situations, commanders could devote more effort to thinking creatively about the best way to deal with a situation and to developing options.

- Commanders will be able to review proposed options both in greater detail and faster than ever before, thus further increasing the likelihood that options selected will be sufficiently well conceived to actually play out in the battle without significant alteration. However, commanders of the future will be required to have a greater understanding of technology and a greater facility for working with automated tools.

Organizationally, hierarchies will flatten to facilitate the flow of information and decisions while the role of staffs will be greatly diminished, their work being largely automated. Further, there will be an increased premium on interoperability to ensure that we get the greatest utility out of our resources. Technically, we will shift the emphasis from a reliance on bandwidth to communications connectivity and processing power and will be increasingly dependant on "intelligent" software.

The changes in both C^2 and in the form of warfare as we would prosecute it promise considerable economies. This leads to the conclusion that the investment necessary to move towards DBK is worth very serious consideration within DOD. The investment required is more than just R&D funds or system procurement dollars. It also involves a commitment to the kind of change in our organizational structures and doctrine that will allow us to both take advantage of the opportunities afforded by having DBK and the economics that are associated with a new approach to C^2.

DBK AND FUTURE WARFARE

Jeffrey Cooper

New decision aids, intelligent agents, simulation, modeling, and forecasting aided by artificial intelligence and fuzzy logic permit large volumes of data to be collected, processed, and displayed without swamping users. Data correlated becomes information. Information converted into situational awareness becomes knowledge. Knowledge used to predict the consequences of actions leads to understanding. Thus the cognitive hierarchy.

A DBK, defined not as data (the transparent battlefield) but as knowledge (a significant exploitable asymmetry) offers powerful implications for the organization of warfare. DBK provides synoptic integrative knowledge, not just data on discrete objects and events. DBK lets its possessors pierce the fog of war and thus master the unfolding progression of circumstance, decisions, and actions in the battlespace; it puts commanders in real-time command. C^4I is converted from mere coordination to the orchestration of combat power focused on decisive points. Those who respond rapidly can acquire the advantages of initiators but avoid the vulnerabilities to which initiators expose themselves. Thus the historic balance between offense and defense is altered.

Introduction

DBK can be applied at one of three levels:

- At the shallowest, it could be appliquéd onto present operational concepts and organizational structures (e.g., as the value of turning inside the enemy's cycle was demonstrated at 73 Easting, a land battle in the Gulf War). Effectiveness would rise without affecting the basic conduct of operations.

- It could underwrite a Reconnaissance Strike Defense Complex (RSDC) so that long-range precision strikes could substitute for closure and close combat.

- At the deepest, by supporting joint integration, it could promote coherent operational concepts to win operationally decisive engagements that provide strategic results.

- The deeper the application, the more that operational concepts and organizational structures must change.

DBK (plus advanced communications) can alleviate classic span-of-control constraints and allow command structures to be delayered to improve, rather than impede, flows of critical information. Many intervening filters hitherto needed to process information and control subordinates could be replaced by automated decision support systems that respond directly to the battle commanders. Local information (e.g., detailed health and status updates) need no longer flow up nor or detailed orders flow down.

DBK (plus precision strike) would let U.S. forces threaten enemy buildups prior to invasion. Excellent real-time surveillance capabilities lets us locate, track, and target

enemy mobile forces and their critical logistics and C^4I infrastructures. We could place their forces at risk rather than going after static (but easy-to-find) centers of gravity and chancing collateral damage.

Our response to Iraq's October 1994 feint illustrates the current practice of interposing U.S. forces in response to hostile acts. Unfortunately, as our overseas bases close and forward deployments draw down, our forces have to move farther to contingencies. Intervention costs more and takes longer and is thus less viable against repetitive or continuous threats. If we could get the same result by coupling smaller on-scene forces (so that opponents would still have to mass for attack) with devastating counter-concentration attacks staged from over the horizon, DBK would prove a powerful deterrent.

Although DBK will be implemented according to the commander's vision, it assumes a common set of capabilities and requires a core set of supporting systems (among them, wide-area sensors and fast processors). Unfortunately, DBK cannot be appreciated within the present framework of stovepipe operations and piecemeal analyses. They require a shift in focus from individual elements of combat power to their integration.

Defining DBK

The synoptic vision of DBK lets commanders:

- Forge a common purpose for dispersed combat forces,
- Assess the battlespace accurately by understanding its evolving dynamics and correlated patterns,
- Develop their own adaptive vision of combat operations,

- Project the consequences of their decisions across the space and time of combat,
- Recognize periods and places of potential vulnerability as they evolve, and
- Create, not just find or identify, windows of opportunity that can be exploited.

By so doing, commanders can transcend the classic problems of coping with uncertainty: where to direct personal focus, how to assess prefiltered information (e.g., the directed telescope), how to avoid dependence on preplanned responses to potential contingencies, and foremost, and how to oversee and orchestrate the entire operational area despite its scale and scope. Like a counter-punching boxer, DBK lets commanders exploit the enemy's own initiatives.

One of key functions of command is to allocate resources, including time, to accommodate the progress of the operation and not give the enemy a breathing space through material shortfalls or human exhaustion (see Training and Doctrine Command [U.S. Army], FM 100-5, *Operations*, June 1993.). DBK allows commanders to develop an adaptive intent to unify the activities in the battlespace and let them execute simultaneous high-tempo integrated operations against the enemy's military power and will. Quantity and tempo, in and of themselves, can overload the enemy's command system and generate exploitable opportunities while minimizing casualties attendant from extended, attrition combat.

DBK allows the application of force from multiple media at the right place and time. It supports both *cycle-time* and *phase-control* dominance so that agile and adaptive units can engage and defeat larger forces in rapid succession. By

conducting a seamless, continuous campaign; these tactical victories could not only be propagated throughout the extent of the opponent's tactical echelons, but would also have a *cumulative* impact resulting in decisive victories. DBK is the key to achieving nonlinear combat results. Even tactical units can initiate operationally decisive results, as they did at the Battle of Midway.

Operational-Level DBK: The Adaptive Campaign

If DBK is to be truly *dominant*, it must entail a real-time synoptic vision defined by the relationship among the strategic, operational, and tactical levels of war. Synoptic will be defined not so much by sensors as by the commander's ability to integrate wide area information and comprehend it (which depends on how good the decisions aids are) and by the planning horizon (affected by unit mobility and the reach of the weapons).

The act of acquiring DBK cannot wait for combat; assets such as submarines, mobile missiles, and mine-laying equipment are hard to find and track after units deploy. Battlespace preparation requires data (e.g., near-continuous tracking of enemy assets) to start flowing in peacetime and grow denser as crisis builds. Such data includes enemy orders of battle, tables of organization and equipment databases, and target locations. Because DBK is pointless if decoupled from the will and means to act, this suggests a more assertive posture for the United States to adopt during peace and crises to retain initiative and control, rather than react to the transition to crisis and conflict.

DBK requires that what each level sees is *consistent* (and proportionate to its need for situational awareness), not

necessarily the *same*. Scalability matters, as does avoiding information overload, a potential hazard of DBK systems. DBK must provide location and movement data on one's own forces and enemy forces, and on the complex relationships and interactions between the two. It must allow the relative phase between the sides to be controlled through time-distance relationships.

Tactical DBK: Coherent Combat Operations

DBK can be particularly useful for tomorrow's war. Combat can be expected to be dispersed, noncontiguous, discontinuous, and nonsequential, characterized by meeting engagements (rather than planned assaults and defenses) and heir to the rapid propagation of success and failure. Hitherto, the purpose of linear deployments was to maintain a continuous front to minimize exposure and vulnerability from flanks and salients. Nonlinear tactics try to do the same by reducing exposure times and using coordinating units to provide cover. Coherent operations provide leverage to tactical initiatives as they are exploited by a fully integrated, adaptive force capable of seizing them in real-time. A nonlinear battlespace requires different skills of both senior and subordinate commanders.

Cycle-Time Dominance: DBK improves the understanding of critical combat dynamics as they occur so that they may be translated into timing and spatial cues for tactical actions.

Many analysts have returned to the Observation-Orientation-Decision-Action (OODA) Loop (see Col John R. Boyd, USAF [Ret.], *A Discourse on Winning and Losing*, August 1987) to understand the potential impacts of the Information Revolution on combat operations.

Unfortunately they have focussed on the decision side rather than the action side. Good communications are analogous to Boyd's key technical requirement for 3,000 psi hydraulics, to link a pilot's rapid decisions to his aircraft's performance. As with air combat, small advantages in each maneuver action ultimately result in a decisive firing solution. This is particularly attractive for repetitive action/response cycles in combat. Time becomes the critical determinant of combat advantage.

Phase Dominance: But what shorter cycle times really achieve is to let U.S. forces to select the right time to engage the enemy so as to maximize differences in relative combat capabilities. Phase-Dominance builds small advantages into decisive victories. DBK informs commanders of the natural operating cycles and rhythms of enemy forces (as well as their own) and ensures that actions can be executed exactly when needed.

Maintaining the coherence (a combination of mental and physical concentration) of combat units is never easy—especially when they are forced to alter their state in combat (one reason why the reorientation conducted by the 20th Maine at Little Roundtop is considered a classic). Armies change their tempos and shift back and forth between road march and assault formation; between defense against air to defense against ground; or from either to offense; from one objective to another, especially in meeting engagements. Each change not only perturbs unit coherence but risks a loss in the essential phasing between the integrated joint forces that produces overall operational coherence. It requires a different mental attitude and task sets—a resetting of the cycle. The coherence of an organization takes time to reestablish (this might be called

a phase-change time-constant). In the interim, the unit cannot act in focus and is more vulnerable.

Surprise works because it comes from unexpected directions, but a larger reason is that it hits at unexpected phases in the operational cycle; it forces an unexpected and disruptive phase-change with the attendant loss of coherence while re-orientation is taking place. Thus, U.S. dive bombers caught the Japanese carriers by surprise at Midway during their extremely vulnerable refueling and rearming phase of cyclic operations.

Real-Time Learning

In the Cold War, the U.S. developed a detailed understanding of Soviet equipment, order of battle, doctrine, concepts of operations, and tactics. We observed their large-scale training, tests and experiments, and read their military texts. Thus, we could train and exercise against them (or their protégés) with great realism. We also knew the battlefield. Our soldiers in Germany used to boast that they knew every rock and tree between the Inner-German Border and their positions. Similarly, submariners, as much as anyone, recognize the need for details of the operating area (such as thermal layer depths, bottom features, and even seasonally changing biota) that operational, on-scene experience alone provides.

With some exceptions (e.g., North Korea), we will lack these advantages against tomorrow's enemies. With today's threats so diverse, such familiarity must be acquired much faster. Real-time learning will have to be substituted for intelligence—a new requirement that must be factored into DBK at all echelons. It also helps to know how others may respond to your moves; this helps define the size of the battlespace and focus the resources behind DBK. This

creates a need to educate everyone simultaneously about enemy tactics, concepts, equipments, and system capabilities—with profound implications for professional military education and training.

Jointness

The classic approach to jointness used discrete units from the services, but separated them in time and space through Fire Support Control lines. This reduced mutual interference and allowed each force to operate tactically by itself. This model eased problems stemming from limited real-time situational awareness and communications that complicated coordinating diverse forces. The problem was that joint capabilities were simply *additive*. Admiral Owens, for instance, posited two paths for jointness (see ADM William Owens in "Living Jointness," *Joint Forces Quarterly* [Winter 1993-94]: 7-14). The *specialized* path uses the best qualified force component for a given mission; the more effective path, *synergism*, was created by "combining forces in such a way that higher outputs (combat effectiveness) result than could be achieved by simply adding the outputs of different forces." His analysis suggested the two were fundamentally different paths rather than one dimension with different degrees of synergy and effectiveness.

Because the U.S. defense drawdown makes overwhelming force much harder to field, joint operations are required for effectiveness and efficiency. Intuitive acceptance of integrated joint forces and dependence on non-organic, non-controlled resources and capabilities are also needed. Integrating U.S. forces from different media forces opponents to counter multidimensional, multifunctional operations, but they also create opportunities for exploitation by different elements of the force at the same

time they cloak vulnerabilities and disadvantages of operations conducted in single medium.

Synergy comes from focusing on a common *tactical* objective, employing common doctrine, synchronizing the tactical echelons, and providing mutual support. Its prerequisite is that it requires integration at lower tactical echelons and thus demands greater situational awareness, broader understanding of operational progress, and greater adaptability in procedures.

Coherent operations conduct combat as a single process with an integrated unit operating in-phase to amplify its power, exploit opportunities in real time, and get inside the opponent's cycle times. Integration cannot work without defeating the friction inherent in operations conducted by diverse forces. Phase-related differences in operating cycles among joint forces tend to explain the difficulties in managing joint operations. Subtle factors affecting when phases change and how long it takes help in understanding how to execute operations coherently.

The ability to see, understand, adjust, and communicate better and faster is the foundation of integration. DBK provides these essential tools; it enables force integration and reinforcement without pausing for synchronization or mutual interference. This gives joint forces all the advantages of a single organism (e.g., cycle-time advantage) while retaining their underlying diverse capabilities (see Jeffrey R. Cooper, *The Coherent Battlefield*, SRS White Paper, Arlington VA, June 1993).

For that reason, complex systems operating at the edge of their performance envelope require their feedback loops to function well, which means fast, tight, and predictably. Delays can delink adaptive corrective actions and

knowledge of their effects. It is also difficult to maintain coherent processes in excessively slack systems. They are heir to *unpredictable* overshoot and undershoot because of imprecise control or prediction. DBK offers unique opportunities to maintain the real-time, close-coupling required for feedback loops to assist in leading a flexible, dynamic campaign.

The key to conducting complex joint operations coherently is timely communication of the commander's intent so that the entire hierarchy shares a consistent vision and objective. DBK will provide tools to reinforce the traditional role of command exercise by promoting a shared timely image of the battle (a combination of intelligence and status indicators) even as it adapts to an evolving battlespace.

C^4I Systems and Architecture Impacts

Changes in the locus and focus of decisionmaking will change the nature of the transmitted information: intelligence support, issues, data-types, and channels.

Decisive Combat: The most fundamental changes in warfare may be the return of Clausewitzian decisive victories in place of attrition warfare. The latter paradigm, exemplified by World Wars I and II, were waged by large, relatively equal, industrialized nation-states, and won largely by material and mass, not by *coups de main* or great battlefield victories (even those like Kursk and Stalingrad).

DBK lets commanders exploit seams in the enemy's forces, gaps in his abilities, and openings provided by his sequential operations. Forces and fires can be rapidly reassigned between holding, breakthrough, and exploitation operations. Opponents can be kept from maintaining the

coherence of their forces so that the United States avoids the need to take on enemy forces *en bloc* (as General Sullivan noted of Operation *Just Cause*). Mobile, lethal, and rapid operations conducted in parallel could let U.S. forces defeat units in detail at a time of our own choosing across the battlespace. The other side can act only in a pre-planned but uncoordinated manner in the face of our initiatives. The result may thus resemble the classic *coup de main*, except not executed as a single main-force engagement but a parallel set of tactical operations.

Throughout the Cold War, the United States worried about fighting outnumbered. Its strategy against the Warsaw Pact coupled quantitative advantages and *sufficient* size to dissipate the momentum of the Pact forces through tactical nuclear weapons or later *Active Defense*. Only with *AirLand Battle* (1983) did the we begin to think of decisive strokes with conventional forces.

In the brief period between the Wall's fall and the Drawdown, there remained enough overwhelming Force to wage *AirLand Battle* against regional opponents such as Iraq. Efficiency in deployment and sustainment of massive force rather than effectiveness in force application was the critical problem. With the Drawdown the latter is essential. DBK permits limited forces to be an effective instrument of war by allowing the conduct of decisive combat.

Altering the Command and Control Paradigm: Many suggest that high-tempo complex simultaneous operations does not let the commander control forces effectively. Command has to be automated through preplanned courses of action and rules of engagement. Yet true integration demands the reinforcement of commanders in exercising real-time command *during* combat. This, in turn requires

reexamining the current paradigm that treats *command* and *control* as inseparable. Exploiting DBK demands decentralization of command authority and a concomitant relaxation of control at the higher levels. Existing organizational structures (themselves reactions to earlier C^3I shortages) reinforce the tight linkage between command and control, as well as classic distinctions between strategic, operational, and tactical operations. The need to support seamless, continuous, parallel operations also requires modifying the C^4I architectures that support the command structure.

Counterpart adaptations in commercial firms have taken so long because technologies were used to increase efficiency in performing the old tasks, rather than reengineering the entire process. Exploiting the DBK is likely to require similarly fundamental changes in military operational concepts and organization structures.

Vulnerabilities

If DBK centralizes sensor fusion and decisionmaking it can introduce new vulnerabilities. If it is built on decentralized decisionmaking and exploiting, vulnerabilities may be reduced; there will be fewer nodes that can affect the entire operation if corrupted.

DBK offers the ability to focus on key battlespace activities. But loss of critical focus may be induced by phase-change information overload, or self-induced distractions. In tomorrow's high-tempo battlespace, the opponent's C^2W activities need only to distract or delay momentarily for critical focus to be lost. IW may cause loss of lock (a reason for revisiting the extensive Soviet literature on *Radio-Electronic Combat*). Vulnerability

assessment, while warranted, must be considered as part of integral operational design, not merely overlaid as a stand-alone, counter-counter-measure plan.

Comparative Advantage

Because DBK is largely built from commercial systems, it is available to others. Whether or not the technology itself gives the United States an advantage will depend on who uses it well. Unfortunately, our intelligence community has had more success tracking system capabilities than in predicting how well others could use them—which, for DBK, depends on complex questions of organizational cultures and adaptability difficult for outsiders to predict.

Nevertheless, because the information revolution is real, most elements of DBK are inevitable. Whether we can harvest this revolution and strengthen our national security is a matter of choice; so is the selection of focus and means of implementation, which, in turn, depends less on enhancing the individual piece-parts than on integrating all elements into a synergistic, effective organization. These issues demand the most serious consideration.

DBK WITH AUTONOMOUS WEAPONS

Michael Sovereign

DBK alone is meaningless. Military relevance comes from the ability to hit what you can see. To do this it is necessary to analyze the synergy of DBK and a new class of autonomous weapons in a canonical scenario—what might have occurred if Saddam Hussein's lunge in October 1994 had not stopped short of the Kuwait border. Although DBK can deter, the assumption in this case is that it did not; the issue is whether DBK mated to autonomous weapons can let the United States win in a timely manner, without major deployment or without having to buy new platforms. Autonomous weapons—sensor-fuzed weapons (SFW), brilliant anti-tank submunition (BAT) and wide-area munitions (WAM)—are those needing far less human guidance than earlier weapons and promising a high P_k if placed within range.

Prior Studies

Most prior studies suggest that armored thrusts can be stopped from the air alone using autonomous weapons. Examples include RAND's "The New Calculus" and "The Use of Long-Range Bombers to Counter Armored Invasions" and similar studies by Jasper Welch, Major General, USAF (Ret). A more recent study by OSD (S&R) examines the kill rate from U.S. forces on hand (plus those that can arrive over the next few weeks) in a scenario similar to *Vigilant Warrior*. They concluded that despite

high kill ratios, most of the vehicles would reach Kuwait. A McDonnell-Douglas study showed similar results but a lower kill rate. Recent studies by JCS and the Navy suggest that more than one kill per sortie can be obtained even from today's unguided cluster munitions (v. the .01 rate in the Gulf but that mixes all types of sorties together).

Recent work by Dr. Raymond Macedonia suggests that sensor-fuzed weapons (SFW) can generate powerful results if wide area mines are placed in attack corridors; attackers are forced to slow down for mine-clearing (and risk being hit from the air) or take large casualties from the mines themselves. Advanced WAMs could be used to help target more mines or guide SFWs. Commanders with DBK could deploy thin lines of WAMs and use the feedback to call in more SFW or ATACM-based WAMs—even under bad visual conditions that might frustrate DBK.

Study Parameters

The results of the study are predicated on a careful definition of DBK and a reasonable characterization of autonomous weapons.

DBK is the upper limit of what intelligence systems 10 years hence can be expected to do. It entails the precise location of enemy units and their general status, but not the status and location of each platform. The location of mobile units can be known intermittently, but they do move over time. Not all this data will be known instantly by all units, nor is it equally available from difficult environments or in the face of countermeasures. There would remain a gap between DBK and actual targeting that may require additional local information, man-in-the-loop, or very intelligent weapons with terminal guidance capability.

The benefits of DBK are that it:

- Removes uncertainty as to whether an attack is underway
- Gives the location, composition, and status of the attacking units
- Ensures sufficient knowledge on friendly units.

During the Gulf War, the United States came close to achieving DBK at the outset of the air war. This knowledge, however, took a long time to acquire and degraded as soon as air actions raised uncertainties about the results. While DBK was not achieved for the ground war, JSTARS helped provide a real-time ground picture for the first time.

DBK does not mean that all U.S. units would be in *continuous* possession of sufficient targeting information; *that* would require perfect C^3, great mobility, and survivability. Direct-fire weapons, whether ground or air based, require more than DBK. They also need delicate and time-consuming reconnaissance, surveillance, targeting and maneuver actions, plus fast expenditure rates and therefore heavy logistics to produce sufficient kills.

First-generation PGMs (e.g., laser-guided bombs) reduced the logistics requirements of combat but still required precise target information; they also put the designator and the platform at risk. Autonomous weapons, though, can be targeted with less precise information and in some cases (e.g., stand-off delivery) do not even put the launch platform at risk. DBK is needed to generate taskings, but the timing of mission scheduling is no longer so critical because moving targets can be localized again.

Autonomous Weapons

Autonomous weapons can select their own aimpoints and are available in quantity. Even though redundant kills reduce efficiency, overall kill rates can be high.

- **BAT** is a 20-kg, self-guided (acoustic and IR) antitank round with a large acquisition area that permits a high P_k even when launched from medium altitude or from stand-off (e.g., MLRS, ATACMS, Tomahawk, or JSOW). Now in early testing, it is expected to cost less than $100,000 per copy but is unlikely to appear in large numbers before 2000 absent a more aggressive procurement cycle.

- **SFW** is a smaller, self-guided IR hit-to-kill round with a smaller acquisition range designed for counter-battery applications, MLRS and ATACMS delivery, or low- and medium-altitude air drop. It is low-rate acquisition with a $20,000 price tag.

- **WAM** is a 16-kg mine capable of launch an SFW to about 100 meters. It can be remotely controlled. An improved version may be networked as a sensor field. It is designed for ground, artillery, or air delivery (an anti-helicopter variant is being developed). It is projected to emerge from engineering development in 1996 and cost $25,000 per copy.

Order of Battle

Using the Iraqi feint as a base, the following target set is assumed:

- 4,000 armored vehicles
- 200 high altitude SAM sites

- 100 C3 sites
- 20 long-range radar sites
- 20 airfields
- 200 SCUD support sites
- 80 infrastructure nodes

U.S. forces consist of:

- 30 aircraft (F-15 and F-16) on hand because of the continued Southern Watch operations.
- An aircraft carrier with 50 attack aircraft is nearby.
- 100 long-range bombers from CONUS and Diego Garcia armed with sensor-fuzed munitions dispersed from wind-adjusted tactical munitions dispensers (WATMDs).
- 18 Apache helicopters (with Hellfire) out of Kuwait.
- 24 A-10s (with Maverick, rockets, and 30mm) out of Kuwait.
- Two reinforced brigades (to implant WAM) supported by MLRS and ATACMS (with SFW) as well as tube artillery with laser-guided projectiles (includes Allied ground forces).
- Another 100 aircraft within 5 days.

Other assumptions include:

- Air superiority is not an issue except near Iraqi air defense units

- It is assumed that air attacks are launched from medium altitude to keep attrition low.

- There is enough strategic warning to permit loading up on weapons (which are otherwise too sensitive to keep in the Middle East on a permanent basis).

- No countermeasures were factored in even though anything that is a great advantage for one side will become a potential target for the other. In practice, the instruments of DBK will be attacked, dispersion will be used to frustrate autonomous weapons, and information warfare will be used to introduce delay into the sensor-to-shooter cycle.

Table 1 contains the various weapons, operational load-out, and effective *mobility* kills per sortie (assuming a P_k of 50 percent). Sortie rates over the first 10 days are three a day for helicopters, two a day for fixed- wing aircraft in theater, once every 2 days for bombers out of Diego Garcia, once every 4 days for CONUS-based bombers. Launch rates for ATACMS and MLRS are 200 a day total. The figure in parenthesis is nominal kills per sortie, the difference reflecting wastage due to multiple submunitions targeted on an aimpoint. See the Appendix for a more detailed discussion of the difference.

The basic results, shown in the right-most column, indicate that a modestly size air attack force, if not otherwise diverted, could kill half the targets (2618) in the first day of combat. These rates (four kills per sortie, 2,600 per day) far exceed rates from *Desert Shield* thanks to DBK, autonomous weapons, and the fact that armor, when it moves, is out in the open. No kills were calculated for WAM but they play a large role in slowing down the attack so that sufficient attrition can be effected before Kuwait (and thus cover) is reached.

TABLE 1. Various Weapons, Operational Load-Out, and Effective Mobility Kills per Sortie

#	Platform	Loadout	K/S	Kills/ Day
10	F/A-18	2 JSOW w/3 BAT each	2(3)	40
20	F/A-18	2 JSOW w/6 SFW each	3(6)	120
10	F/A-18	2 JSOW w/8 BAT each	6(8)	120
10	F-14	2 JSOW w/3 BAT each	2(3)	40
20	F-16	2 WCTMD w/32 SFW	3(32)	120
10	F-15E	2 WCTMD w/32 SFW	8(32)	160
20	A-10	Hellfire & 2 Maverick	4(16)	160
50	ATACMS	12 BAT	3(6)	150
50	ATACMS	24 SFW	4(12)	200
100	MLRS	6 SFW	1.5(3)	150
10	B-2	16 TMD w/40 SFW	32(320)	80
90	B-1	16 WCTMD w/32 SFW	25(256)	562
100	Tomahawk	16 BAT	4(8)	400
18	AH-64	Hellfire	4(16)	216

Implications and Limitations

Implications fall into five areas: DBK itself, munitions, C3/training, geo-location, and survivability.

DBK: Even if major military formations can be located, they cannot necessarily be targeted. Environmental constraints, sensor revisit time, the complexity of processing

and fusion, and simple task overloading can result in significant delays before C^3 systems get their information. Many sorties will be working with out-of-date information on mobile units. Even autonomous weapons require a degree of target localization that delays deny them. The status of targets is also hard to assess. Battle damage assessment was difficult in the Gulf War. The ability to fuze videotapes from guns and laser-guided bombs should increase our ability to know what these weapons do, but autonomous weapons present new difficulties (no one is necessarily looking). If battle damage assessment is bad, autonomous weapons will not work as well. WAMs used to see which vehicles are moving may help BDA.

Autonomous Weapons: Although good munitions made the scenario work, the U.S. military traditionally holds off on buying high-end munitions preferring to wait until they get better or cheaper. This strategy may work for long wars but not short ones. This scenario needs between 10 and 20 thousand autonomous weapons to work. Delivery systems will cost more if they have to be stand-off (e.g., Tomahawk JSOW), but even so, they remain cheaper than new launch platforms.

C^3 and Training: Sensor-to-shooter delays degrade DBK (a motivation for the other side's IW efforts). DBK is also degraded if tactical development and training do not keep up with new systems. Joint training and exercises are implied because of the global nature of DBK and the mix of forces that must be on scene to carry out this scenario.

Geo-Location: The conversion of DBK to targeting requires platforms be aware of their own location, speed, and acceleration in three dimensions. Thus the vulnerability of GPS matters.

Survivability: Attack forces, DBK equipments, and their supporting C^3 infrastructure all must survive enemy attack to make the scenario work. The small U.S. forces could be suppressed, attacked, or diverted (e.g., to SCUD hunts) by unexpected enemy capabilities. Often a stand-down is necessary to fix problems.

Appendix

Although the number of weapons on an aircraft is subject to physical limits (weight, attach points, etc.), maximum payloads are rarely achieved because of the tradeoff of weapons for fuel, inventory limits, and the possibility of having to drop a load for tactical reasons. The number of BAT submunitions, for example, is limited by the desire for flexibility depending, the model of aircraft, internal versus external carriage, and other factors.

A more careful analysis would consider the geometry of attack and the target set. Delivery means also matter—e.g., whether a standoff launch can be achieved that surprises the enemy and therefore precludes the dispersion of targets. But tactics are hard to anticipate for any scenario.

The translation between nominal and effective kills per sortie must take many factors into account:

- The delivery of sensor-fuzed weapons from tactical munitions dispensers from medium altitude will probably waste most sub-munitions; they are unlikely to make contact unless targets are parked close together.

- BATs have a greater acquisition rate than SFWs, and their search behaviors can be adjusted; thus their kill rate is higher

- A night-flying B-2 can drop the same tactical munition dispenser of SFWs with many kills because its radar target mapping is accurate; with short warning time, targets are not likely to be dispersed.

- Stand off-weapons such as the SLAM (a Harpoon variant) and JSOW will provide a low wastage rate because they carry small numbers of sub-munitions and are individually targeted from so far off that they will result in similar surprise.

- TMDs and Tomahawks carry large numbers of sub-munitions are inherently subject to wastage rates as high as 90 percent if the submunition has a small acquisition area (e.g., SFW). With several minutes of free fall time, they are affected by wind and are therefore inaccurate. Wind-corrected TMD can be accurate from higher up if the target location is well known at launch time. Their guidance works off GPS and would best served fixed targets and those identified by radar target mapping.

- JDAM is a GPS-guided weapon comparable in punch to the Mk-82 series of bombs. When dropped from high altitudes, it can achieve surprise, but moving targets may depart from their original location in the meantime (unless the bomb is updated in flight). Thus JDAMs are likely to be used against fixed targets (except from B-2s which can fly low at night). Both JDAM and WCTMDs can carpet bomb an area.

- MLRS and ATACMS can operate with low wastage of SFW against up-to-date locations of concentrated but surprised forces or against fixed targets. But under current conditions they would have a high wastage against moving armored columns.

JUST-IN-TIME WARFARE

James Hazlett

Previous chapters have looked at DBK with the assumption that the U.S. Armed Forces had enough platforms and weapons available to prosecute targets, and enough time to get them all into theater. Two previous papers indicate that the equipment necessary to stop an armored column is well within expected future force levels. Another suggested that this fact would persuade enemies to eschew conventional massed attacks entirely and revert to *sub rosa* incursions using military assets masked as civilian ones.

This chapter presents a new philosophy of warfare, "Just-in-Time Warfare" that DBK makes possible. It examines the role of potential reconnaissance-strike-defense complexes (RSDCs). In future information wars, virtual reconnaissance, strike, and defense would be coordinated in battles fought as "meeting engagements" where both sides are on the offense. With requirements to shift between offense and defense in minutes or seconds, only multipurpose systems practicing "just-in-time" warfare will survive. Military systems providing communications, multi-source intelligence, early warnings of tactical and ballistic missiles, and navigation will be vital. Planners will have to coordinate reconnaissance, strike, and defense missions together, over information-and-orders data networks, linked primarily through outer space. The requirement to switch roles quickly makes time precious and coordination an even finer art. Warriors will have to synchronize schedules and orders, as well as deliver military operations to meet rapidly

emerging demands. Turning inside the enemy's decision loop will determine success or failure.

To develop this capability, we must develop new procedures, equipment, and information systems, plus provide better training. Only when the U.S. military becomes learning organization—and all that this concept implies—would it be able to enjoy an advantage achieved by establishing a clear and favorable differentiation from the competition.

In the business world, just-in-time means less work-in-progress (WIP), less overhead, less inventory at each stage of production, and less slack time in the system. In military terms, just-in-time uses DBK and information technology to produce real-time scheduling to cut the need for today's enormous inventories. More frequent deliveries of smaller amounts of product (i.e., destruction) allow for more flexible scheduling, quicker response, and shortened decision cycles. If the batch size of weapons and other logistics shipments into a theater can be reduced, so will the vulnerability of logistical connections.

Just-in-time suggests that forces need no longer be massed prior to attack. When mass is needed for offensive or defensive purposes, it need take place only at the point of impact. Large formations of ships, planes, or armor can give way to staggered scheduling and positioning that present no discernible pattern to an adversary. Not being able to sense where the attack is coming from—because it could come from everywhere at any time—takes away the other side's initiative. Putting the adversary in a defensive, reactive mode simplifies our problem and complicates his. It implies synchronizing, planning, scheduling, ordering and delivering military operations as needed to meet currently emerging demands.

Massing at the point of impact and just-in-time techniques can be applied to command, control, communications, information warfare and logistics.

Command

Just-in-time warfare requires sophisticated yet flexible command, control and information systems. It is possible to link these systems in an RSDC responsible for managing just-in-time warfare across the entire theater of operations. Such an RSDC would be a virtual rather than real organization. It would draw its strengths and inputs from, and send its outputs to, other organizations via high-speed, robust data networks.

RSDCs would link organizations to exploit fleeting opportunities on the information terrain. Commands would contribute whatever skills, access, and access they do best, creating a best-of-everything organization, with world-class elements unavailable to any single one. Standardized memorandums of agreement and understanding (MOA/MOU) could facilitate these lash-ups.

Operational Control/Operational Command (OPCON/OPCOM) arrangements would be less permanent, less formal, and more opportunistic. Organizations would band together to meet specific opportunities and may disband or relocate when the need evaporates or circumstances change. Virtual organizations would cause the services to rely far more on each other and require far more trust than before. They would share a greater sense of co-destiny (or if done wrong, co-dependence). Thus would traditional boundaries of the services be altered. Dense and frequent cooperation among like elements, suppliers, and

customers will make it harder to determine where one organization ends and another begins.

An RSDC, to be optimized, must be viewed as a value-adding partnership (VAP) and transcend today's interservice rivalries. The services have gone about as far as they can go with regards to vertical integration—information flows very quickly and effectively from top to bottom and back. But cross-service flow is another matter. The technologies now exist that permit communications among the services at all levels instead of just at command centers.

If the services and agencies that provide the various technologies and expertise at each point in the engagement cycle are perceived as partners rather than competitors, then each step in the process can be optimized to match with those before and after it. The services and agencies must come to the realization that they have a major stake in each others' success. Given the present and near future states of possible computer-information-communication system integration, it is possible to incorporate this value-added chain into a virtual information data bus.

Digitized information (video, visual, data, audio) will be inserted by the sensor and intelligence systems, ride the RSDC data bus, and be modified by target sequencing algorithms. Modifiers can be injected across the bus as needed (e.g., alter all report data meeting the following criteria). Users (weapons/platforms) would draw only what affected them—a determination that could be made immeasurably more efficient by filters, artificial intelligence, and user agents. Information could be stored in a format that could go from initial report through the identification, decision, assessment, assignment and engagement/reengagement process with information itself modified only at the point of extraction.

Ultimately, the energizing of appropriate circuits, following paths of least resistance, most reliability or redundancy, or fastest route to engagement(s) could be done, to a large extent, automatically. Weapons-to-target pairings could be computer selected and ordered under a command-by-negation (CBN) doctrine where each engagement would proceed to its successful conclusion (or reengagement), unless humans intervene, or because the system recognizes that the engagement violates commander's rules of engagement, coordination, or priorities.

Control

Automating C^2 functions helps free commanders to deal with the choices that systems cannot handle. Fuzing multiple-source intelligence and battle damage assessment generates information beyond the reach of any single sensor. The ability to do this in parallel would free forces from the current sensor-organic weapon lock (sensor and weapon hard-wired to each other on the same platform). A variety of sensors could pair with a variety of weapons on the fly. Sensors and shooters need no longer be in the same place. National, or remote, sensors may have the best picture from which to conduct an engagement. A local sensor may be paired with a theater or national weapon. An Army Ranger could, in practice, be armed with a Tomahawk cruise missile or a Stealth-delivered bomb—the same way that the main battery of an Aegis cruiser is already not its on-board missiles but a Navy F-14, a Marine F/A-18 or an Air Force F-16.

Parallel decisions (rather than one-at-a-time, one-after-another decisions) permit much faster optempo. By inputting mission priorities, rules of coordination and engagement, and an acceptable-degree-of-difficulty, the

commander can set a required confidence level that must be achieved before an engagement is executed. In a touchy face-off with a nuclear-armed peer competitor, a commander might require near certainty. Against a Third-World niche competitor where quick decisive action is required, the commander may be more willing to act on a more-likely-than-not standard, with a low degree-of-difficulty threshold.

Rules of Coordination and Engagement (ROCE) and Mission Priorities

Today, commanders provide guidance through verbal or written, rules of coordination and engagement (ROCE). These rules require a fair amount of interpretation before they can be converted into formats recognized by today's weapons and C2 systems. Computerized ROCE's would help commanders set mission priorities between, say, strike, counter-strike, close-air-support, and defense. These weights could be fed automatically into the targeting and weapon assignment process. By using command-by-negation, automated ROCE's and mission priorities and pre-determined confidence and urgency requirements, computer-generated pairings will give commanders and their staffs more time and freedom to concentrate on the problems hitherto perceived as too hard to handle, or otherwise unanswered.

Communications

Just-in-time warfare requires flattened, virtual organizations. Some of its components may actually remain and operate in the continental United Sates (CONUS), far away from any front. Using communication triggered by orders and information will ensure connectivity without requiring large bandwidth. Communications need not be passed over

continually active circuits. Ships, aircraft, ground units and command centers are bogged down, today, maintaining multiple circuits that carry very little information—most of which is static, and the rest largely unimportant—and certainly not in an optimized format.

Other technologies can cut down on communications loading. Pre-loaded battlefield maps (on CD-ROM or silicon) would require communications only when data changes. This vastly simplifies the problem of picking out the target (thus converting a map into a super moving-target-indicator). Software agents could be used to seek out intelligence on targets—vastly simplifying today's overwhelming correlation problems and freeing much of the process from the slowness of human hands.

User Interfaces

Virtual reality's time has come. A virtual picture (supported by holographic displays and large color screens) of the battlespace may now be more accurate and usable than a real one. Presenting fused information and intelligence as 3-D images which couple weapons pairings and targets (and can be examined from all aspects) will make operations faster and more accurate. Commanders could avoid the mental gymnastics required convert raw data (e.g., lat/long, bearing/range, course/speed) into a mental image. The more easily commanders can interpret the picture, the quicker they can make decisions. It is time targets looked like what they are—not symbols that require interpretation.

Topographically replacing physical geography with infography (e.g., lines of communication) may alter the conduct of warfare. Information peaks and ridges may become the centers of gravity of future warfare. Information

intersections become as important for targeting as nodes or command bunkers,both from an offensive and defensive viewpoint.

Targeting

Paradoxically, total awareness may open the door to greater reliance on dumb munitions. Before DBK, most targets were treated as fleeting. Engagements were conducted even though P_k was low and the degree of difficulty or toughness of the shot was high. With DBK, fleeting no longer means "passing quickly" but "moving quickly." DBK lets us engage threats at the right moment in terms of P_k and degree of difficulty; moving quickly matters less. Dumb ordnance may be deliverable with precision against these new "fleeting" targets, because they no longer disappear.

Real-time targeting, which is possible using just-in-time warfare, can be used with stand-off weapons and dumb ordnance launched from out-of-theater. Bombers and cruise missiles can be assigned en route to the theater. The success or failure of previous strikes, therefore, can be factored in real time.

While still possible, it may no longer be necessary to plan enormous raids to cover large areas to hit moving targets, because speed is no longer important when it cannot clear a target from the area. Real-time targeting allows the designation of a new type of target—irrelevant or inconsequential, ones that are not necessary to attack unless and until they threaten something: platforms with short-range weapons (older generation tanks and aircraft), or systems that need long and easy-to-see preparation prior to use (e.g., liquid-propelled TBMs).

DBK, command-by-negation, new targeting philosophies, and existing automatic engagement systems make it possible to sharply reduce blue-on-blue engagements. Many systems, such as the Aegis Weapons System, were designed to be able to automatically engage massive Soviet raids—last ditch features meant for engagements when no human could decide and act quickly enough. The parameters that had to be met by threats (before they were automatically engaged) were normally very exact. This was done to make undesired engagement less likely and successful engagement more likely. With a new purpose, automatic systems can be used very effectively in an increasingly information aware world. They are microcosms of the RSDC, with "defense" emphasized. If we trusted these systems to make decisions when there was not time for human intervention, why can't we rely on them more when there is time? Many of these systems can and do take inputs from IFF systems. Using IFF systems and other concepts presented here might have prevented the USS VINCENNES (1988) and UH-60 shootdown (1994) incidents.

Battle Damage Assessment (BDA)

BDA is key to the operation of an RSDC and the management of ordnance. During the Gulf War, many targets had to be re-hit because BDA was not available; was indeterminable; or could not be correlated fast enough to a critical or time-sensitive target. Lack of adequate BDA was listed as a problem in the Gulf War Report to Congress for the Tomahawk, SLAM, ALCMs and others.

DBK makes it possible to use BDA more discriminately. Often, the suppression of a target is more important than its destruction. With DBK, a target's reaction to an attack

would be more visible and may suffice for BDA. A retreating target is usually an inconsequential target. Reevaluating the requirements and criteria for BDA would have a direct impact on the amount of ammunition required in-theater and on the engagement process. Today, when BDA determines that a target was not killed, or when BDA is not available, a reengagement is ordered. This may no longer hold, when "fleeting" targets are redefined as "moving" targets and when only targets that satisfy the necessary criteria will be engaged.

Concept of Operations

In WWII, Korea, and Vietnam, U.S. forces took and retook real estate multiple times. This was driven by the need to "take the high ground" and to deal with the uncertainty as to when possession of the real estate was actually required. With DBK, we need only take particular physical real estate when it suits a specific mission for a specific period. The information terrain may become the real battlefield. Battles can become truly nonlinear. It will no longer be necessary to always take the 151st Hill before taking the 152nd. Holding the 152nd might not be so necessary for our purposes, as holding hills was necessary in the past. Tough spots can be avoided, as DBK makes specific objectives (e.g., for stand-off weapons, special operations forces, or information warfare attack) singularly targetable, with the risks from nearby forces clearly quantifiable. Maps depicting troop and weapons employment might look more like measles than spaghetti. The days of the left-hook may be past.

Scenarios

It may be easier to illustrate how DBK can support just-in-time warfare by looking at three scenarios of tactical engagements.

- *Example 1*: National Sensors, Special Operating Forces (SOF) and Joint Surveillance and Target Attack System (JSTARS) aircraft independently detect same Scud transporter erector launcher (TEL) with 50, 45, and 35 percent confidence, respectively. The fuzed confidence exceeds the 55 percent engagement requirement in the CINC's ROCE hook in the data bus. The target is mapped to a visual display with pairing lines made available F-117 Stealth Fighters, Tomahawk, and A-6 Attack Bomber assets. In the absence of offsetting negatives, the F-117s receive heads-up display orders to go to the target; their orders are paired with SOF for updates by verbal-to-text link over data bus (hooks on orders trigger comm-link through data bus). A second event, a short-fuze detection of enemy airfield with impending aircraft launch, trips more hooks in data bus. Again, in the absence of offsetting negatives the F-117s are redirected to the airfield. Based on the Tomahawk's limited launch window, orders to engage the SCUD TEL automatically flow there. Simultaneously, SOF forces get an ancillary charge to provide final phase laser illumination. National Sensor BDA is requested by ROCE hooks but negative orders are subsequently generated as SOF reports visual sure kill. With A-6's paired with combined Marine/Army reconnaissance (RECON)/Ranger team for Close Air Support; final coordination is assigned to Air Force Air Controller in an Army H-60.

- *Example 2:* A patrolling SSBN detects adversary surface action group (SAG) by sonar and reports it via satellite burst transmission. National Sensors are steered to localize and validate contacts; an SSN is asked to close in as well. The SSN visually identifies the contacts and feeds the data to the info-order net for target-weapon pairing, including Inverse Synthetic Aperture Radar (ISAR) images. ISAR and GPS data are fed to the SSN's Tomahawks as well as a closing carrier battle group and a maritimized B-1 wing. Targets appear on visual displays with pairing lines to both the SSN and CVBG. The CVBG orders are negated by the CINC due to a planned surprise littoral strike in support of amphibious landing. The B-1 wing receives orders pairing to SSN for coordinated time-on-target war-at-sea strike by verbal-to-text link over data bus (hooks on orders trigger comm-link through data bus). Based on a high probability of a DUC of SAG, open Tomahawk and B-1 windows and no negatives, orders flow and launch proceeds. The SSN launches a cruise missile. National Sensor BDA is requested by ROCE hooks but before it swings over the area it is called back as SSN-launched BDA-SLCM reports video/radar/IR (infrared) sure kill.

- *Example 3:* A Marine ground commander reports the successful destruction of an enemy irregular infantry brigade with remnants fleeing north into a densely populated valley. JSTARS aircraft, RIVET JOINT aircraft, and Marine reconnaissance teams in the Valley provide independent confirmation. Target correlations trip the 55 percent confidence requirement. Given the population density and low concentration of enemy weapon strike/fire potential, CINC's ROCE "hook" for ground-based engagement to minimize casualties is enabled. GPS-based

> Automated Terrain Assessment indicates a highly probable choke point at a pass that commands the route of the retreating enemy. Estimated time of arrival by the retreating enemy column is 2 hours. "Target" appears on visual display with pairing lines to "available" Army/Marine Independent Action Units (IAU). With no "negatives" given, an Army regiment receives bursted "frag orders" to target; it is paired with a Marine Recon team for updates by "verbal-to-verbal" link over data bus (hooks on orders "trigger" comm-link through data bus). The IAU is paired with a UH-60 squadron entering the area upon completion of a resupply mission. The regiment's commander develops a concept of operation and execution orders by analyzing a 3-D digital target map with real-time updates. Once at the pass, UH-60 and Army IFF transponders continuously update their position over the data bus, providing a moving target exclusion zone. The route there is automatically planned and continuously updated to minimize exposure to ongoing target/weapon pairings. Landing unopposed, the company moves into position, blocks the retreat of the demoralized column, and forces its surrender after a brief firefight.

Conclusion

DBK would permit the U.S. military to change from a vertical, stove-piped, serial, hierarchical decisionmaking to flattened, parallel, virtual decisionmaking and still be able to turn inside any potential adversary's decisionmaking loop. Learning must permeate the U.S. military at every level and be an important part of everyone's mission statement. Employing just-in-time techniques in all areas of warfare, including Command-by-Negation, bursted

communications, smart software agents and smart logistics, and balanced weapons—and the training necessary to use all of these—will make it possible to take full advantage of DBK and the revolution in military affairs.

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